The influence of wind on the distribution, feeding and time away from the nest of greater flamingos of the Camargue, S. France

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CONTENTS.

1.0 INTRODUCTION.

This study is concerned with the foraging behaviour of greater flamingos of the Camargue during the early part of the breeding season April-July 1991.

1.1 FLAMINGOS.

Flamingos, with their pink plumage and strange form are an unmistakable bird. They represent an ancient order of birds shown by fossil evidence to be 30 million years old. The question of their ancestry has long been debated and three hypotheses have been proposed based on details of anatomy, ecology, feather lice and other indicators. These have related flamingos to storks (Ciconiidae), geese and swans (Anseriformes), and latterly, wading birds such as avocets (Charadriiformes) (Olson and Feduccia 1980).

Sibley and Monroe (1990) used DNA analysis to pin-point the closest relatives. This method has classified flamingos between herons (Ardeidae) and ibises (Threskionithidae). Overall, flamingos have an array of behaviours, aspects of their physiology and ecology that are similar to many other groups of birds.

The debate over the classification of the different forms of flamingos into species and sub-species still continues. There are six forms of flamingo world-wide, listed below.

Common name	Generic name	Distribution.
Caribbean	*Phoenicopterus ruber ruber*	Caribbean coast.
Greater	*P. ruber roseus*	Africa, Asia, S. Europe
Chilean	*P. chilensis*	South America
Lesser	*Phoeniconaias minor*	Africa
Andean	*Phoenicoparrus andinus*	South America
James'	*Phoenicoparrus jamesi*	South America

Flamingos are highly specialised birds often living in extreme environments (Ogilvie & Ogilvie 1986). The most striking feature is the pink colouration. This is a result of orange carotenoid pigments being assimilated by flamingos and distributed throughout the body. Only green plants, fungi and bacteria can produce these compounds, yet virtually all other animals require carotenoids as a source for secondary compounds, such as the A vitamins. Flamingos metabolise the precursor orange or yellow carotene pigments acquired from their diet to red keto-carotenoids, the most important being Canthoxanthin (Fox 1975). Carotene pigments are highly photo-labile, but the carotenoids are chelated to the feather proteins of developing feathers where they form a stable complex and provide the colour. These pigments are also found in eggs and fed to chicks in crop milk. A sufficient dietary source of the carotenoids must be maintained for flamingos to produce pink plumes at each moult.

Flamingos exploit habitats that other birds and animals can not tolerate. Such habitats are lakes which commonly have high concentrations of salt or soda. These conditions lead to a low diversity of life forms. However, species that do live in such conditions are abundant as they are often free from interspecific competition, predation and parasitism.

The nature of such lake water means that the amounts of water taken in during feeding need to be kept to a minimum as they can be potentially toxic. Flamingos have evolved a highly specialised form of filter feeding. The adaptations and morphology of all species of flamingos bill have been comprehensively covered by Jenkin (1957) who likens the efficiency of the process to that of the baleen whales. *Artemia salinia* represent almost the sole component of the diet of Greater Flamingos (Gabrion *et al.* 1982, Britton *et al.* 1986). Other species of flamingos feed upon algae, molluscs and even extract organic ooze from mud.

2.0 STUDY AREA.

2.1 SALINES OF SALIN DE GIRAUD.

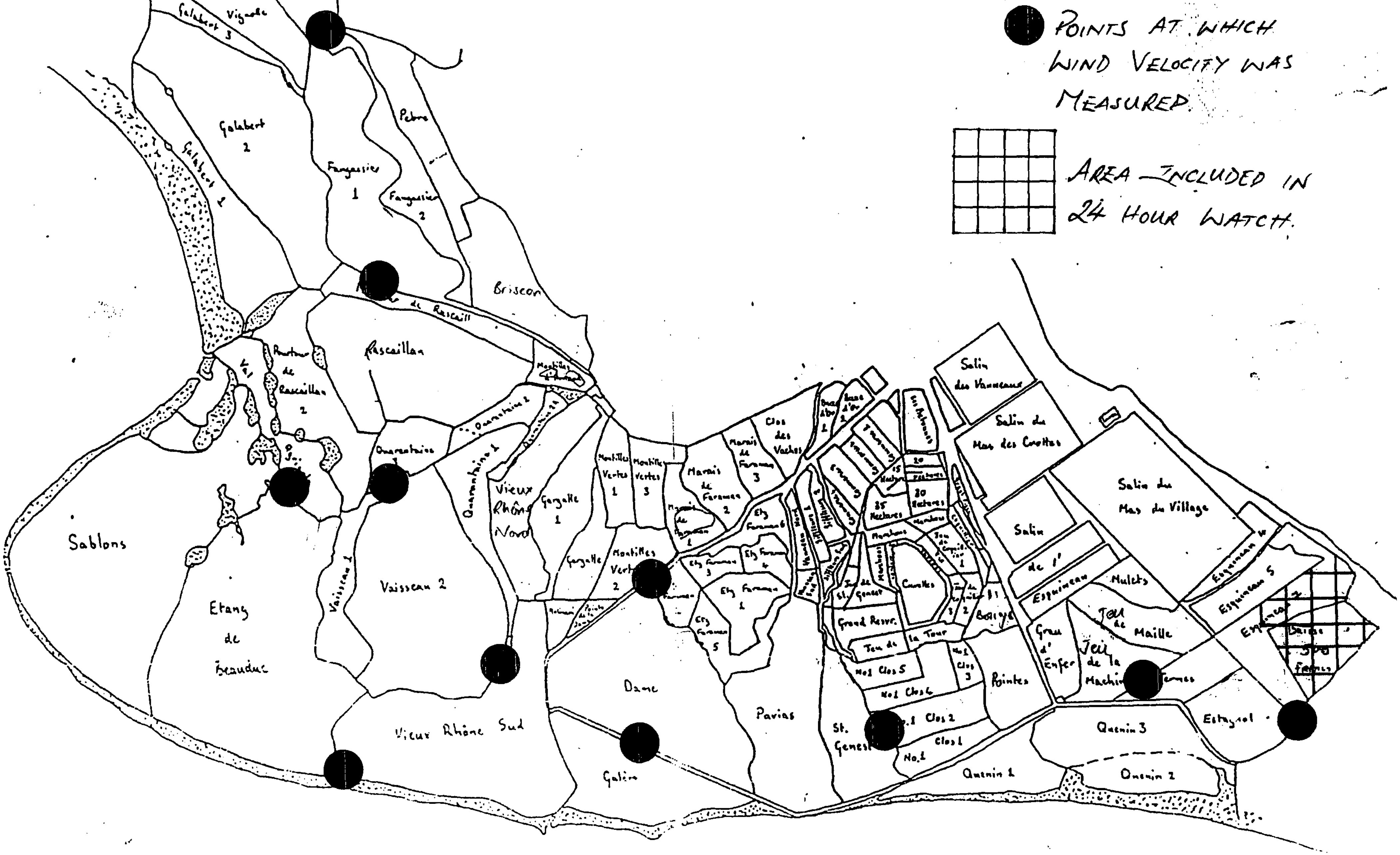
Evaporating sea water to produce salt is one of the oldest industries first mastered by the Egyptians. The Romans created several solar salt works around the Mediterranean basin which use the action of the sun and wind to evaporate water from natural or more commonly artificial basins (salinas).

The modern day salines at Salin de Giraud (fig 1), situated on the Rhone delta, S. France, are the largest solar salt works in Europe. The salt industry in this region has greatly expanded since the start of the 20th century. This is due to an increased demand for salt from the Fos petrochemical works on the opposite bank of the Rhone and the vast demand for salt needed for the Solvay process in the production of soda. Aside from lime (CaO), soda (Na_2CO_3) is the second most widely used basic compound.

At the present time the whole works consists of 185 etangs (lagoons) and covers and area of 12,700 hectares Fig 2.

Salt water is pumped from the Gulf of Beauduc in the spring. The salts contained in sea water are at a density of 37 grams per litre (gl^{-1}). The water gradually passes through a series of etangs becoming more concentrated under the action of the wind and sunshine. Various less soluble salts precipitate out from the water at different densities and finally the water enters the harvesting beds in

Figure 2. A map of the study area, the salt works at Salin de Giraud which are described in the text. The whole works consists of 185 etangs (lagoons) and covers and area of 12,700 hectares. Points at which the wind velocity was measured and the area in which the 24 hour watch was performed are marked.



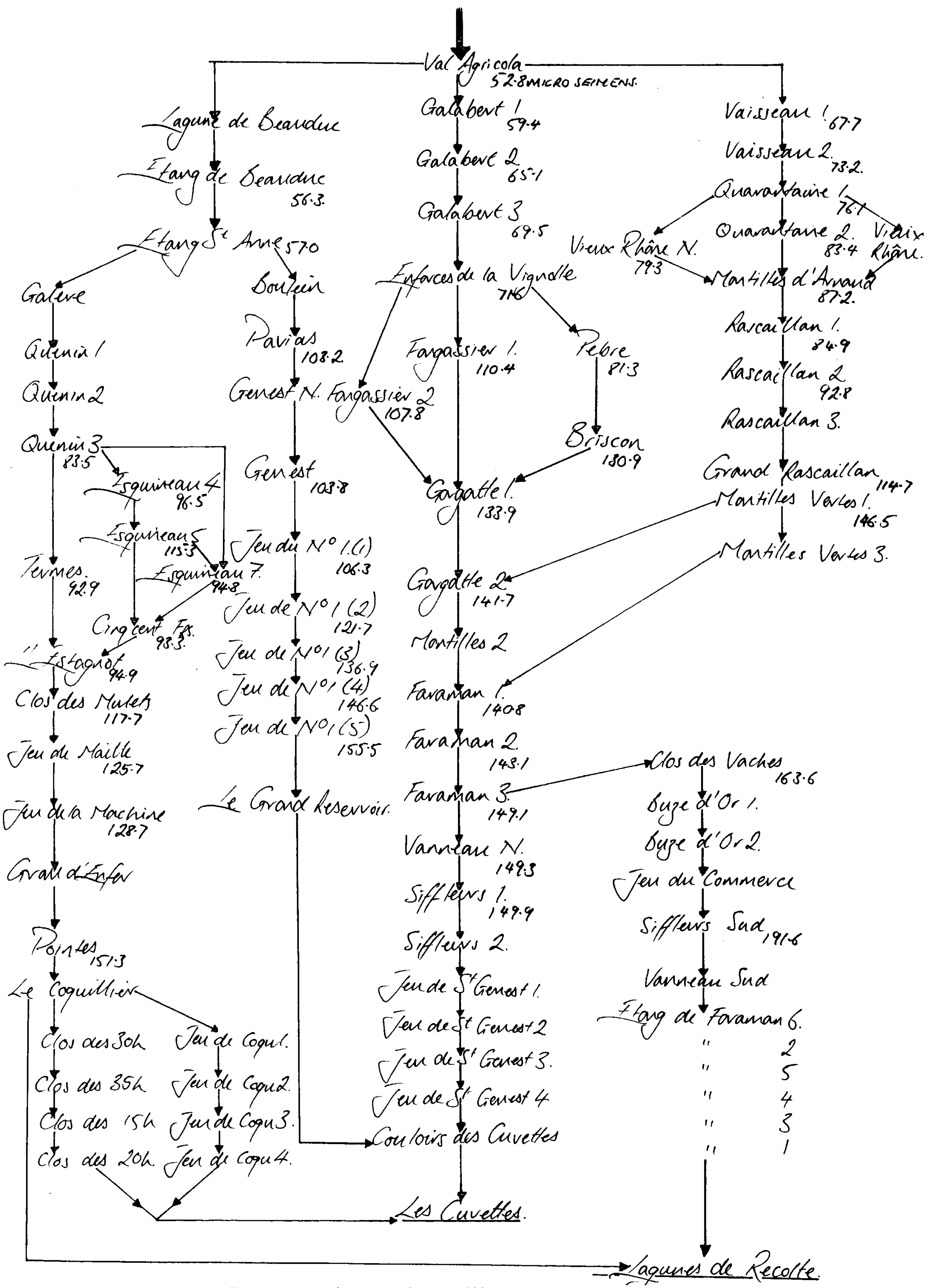


Figure 3. A diagram of the different routes that water can pass through the salines. The values for the mean conductivity (micro siemens) between 12/4/91–12/7/91 of each etang are given.

the east of the works at a density of 320gl^{-1}. The final product is 99 percent pure sodium chloride which is harvested in the autumn just before the average date where precipitation exceeds evaporation.

The flow rates and passage from one etang to another are strictly controlled by pumps and sluices. The density of the water within each etang is measured every day. The rates of evaporation are determined by prevailing weather conditions. To compensate for the different seasons, 3 different length routes through the salines exist (fig 3). During dry seasons a more or less direct route west to east is favoured. During seasons when evaporation rates are not as great, a longer route is required. This level of control maintains the salinity of individual etangs within a narrow range (Gabrion *et al.* 1982)

At the harvesting beds the water is saturated with salt (NaCl). In these conditions only a halophillic green algae *Dunaliella salinia* lives. This species contains high levels of beta-carotene pigment which protects photosynthetic pathways against high light intensity. The abundance of this species turns these harvesting beds pink in colour (plate 1)

An aspect of the climate of the Camargue is the violent N.N.W. wind called the Mistral. This is a regular wind which occurs in bouts lasting several days throughout the year, but is most common during the spring. It can reach force 12 on the Beaufort scale. Traditional houses of the Camargue have a rounded gable end facing N.N.W. as protection against the Mistral. There is also a SE wind which can be almost as strong as the Mistral.

The two winds have a dramatic effect on the climate of the area. Jenkin (1957) reported how stomach samples of Greater Flamingos collected from Camargue, may have been, "abnormal, as none of the birds had managed to collect much food during the 'Mistral' which preceded the investigation".

The strong winds had a dramatic effect on redistributing the water with in the etangs (plate 2) unveiling beaches of mud upwind and increasing the water depth downwind. The wind also propagated sizable waves across the fetch. The disturbance caused by waves could act to restrict flamingos to more sheltered areas of the etangs.

2.2 GREATER FLAMINGOS.

Greater Flamingos are the lightest coloured of all the species of flamingo (plate 3), and they have the widest distribution of all the species of flamingo (fig 4). Populations can be found around the

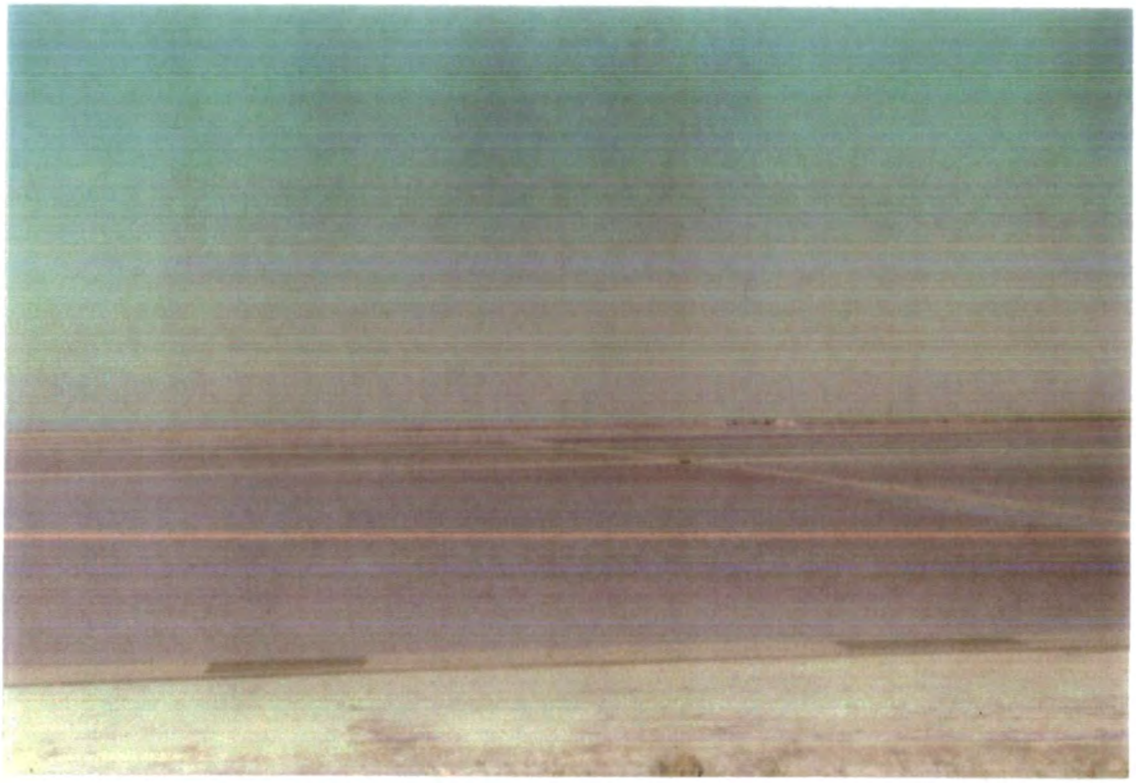


Plate 1. Harvesting beds in the east of the salt works. By this stage the water is saturated with NaCl, and only a green algae *Dunaliella salinia* lives in great abundance. This algae produces much beta-carotene pigment to protect its internal structure from the high light intensity. This results in the water being pink in colour.

Plate 2. This plate shows the redistribution of water within two etangs. On the right hand side there is an increase in water depth and waves are created by the wind in the downwind half of the etang. On the left hand side a vast beach of mud and algae is uncovered when the water is pushed downwind.

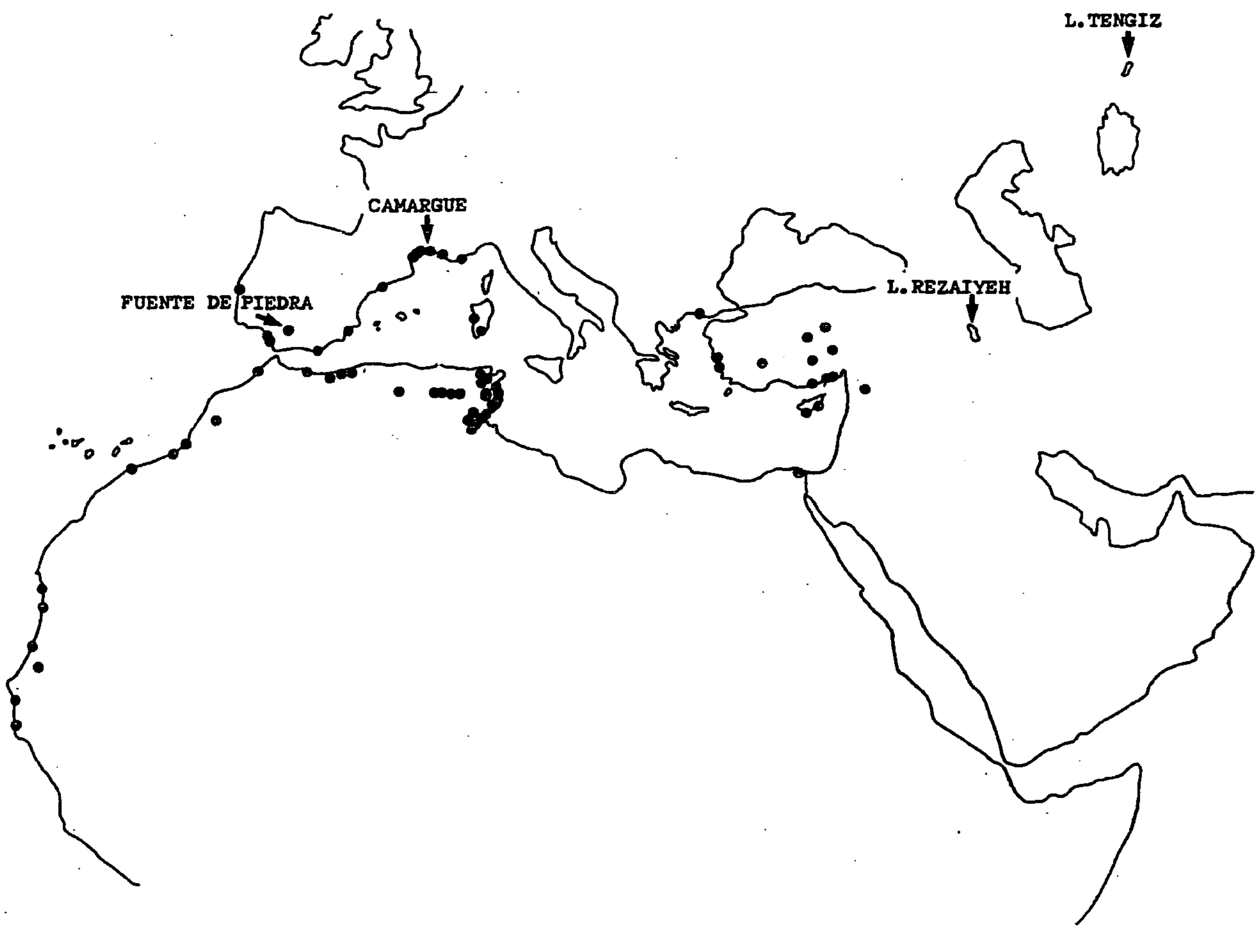


Figure 4. Distribution of Greater Flamingos around the Mediterranean basin and West Africa. The sites marked are regularly frequented by hundreds or thousands of flamingos. Arrows indicate the main ringing sites.

Mediterranean basin, and extending down the Atlantic west coast of Africa to Senegal. Colonies occur throughout the Middle East towards India, and north to Russia where they nest around Lake Tengiz. Further populations are located in south-eastern Africa where Greater Flamingos often co-exist with Lesser Flamingos.

The degree to which these sub populations are separated is not known. Movements of flamingos have been described by Cramp and Simmons (1977) as migratory, partially migratory, dispersive and at times erratic. However, Johnson (1989) states that colonies up to 1,000km apart show considerable range overlap and exchange of individuals.

The Camargue is the only regular breeding site for Greater Flamingos in Europe. Individuals ringed in the Camargue have been resighted in colonies as far apart as Senegal and Turkey.

2.3 GREATER FLAMINGOS OF THE CAMARGUE.

Johnson (1975) states that Greater Flamingos have been present in the salt marshes of the Camargue for several centuries but it was not until Etienne Gallet compiled the Les flamants rose de Camargue (1947) that many details of the flamingos life history and breeding colonies during much of the early 20th century were revealed.

Since the 1940's researchers such as Hoffmann (1954, 1960), Lomont (1954) and Johnson (1989) have maintained a series of studies which have provided a great insight into the behaviour, ecology, conservation, winter movements and population dynamics of the Greater Flamingos of the Camargue.

Johnson (1975) states how the flamingos have benefited from the expansion of the salines. Within the salt works purpose built islands have been constructed and maintained (Johnson 1982) and the series of shallow lagoons of increasing salinity provide accessible food for many species of bird.

2.4 *Artemia salinia.*

The brine shrimp *Artemia salinia* is found in salt water throughout the world. Cysts of *Artemia* hatch in Febuary-March once water temperatures reach above 10^{o}C. Most of the reproduction throughout the season is parthenogenic. Females produce fragile eggs which hatch directly. Other thick walled cysts are produced from June onwards. By October the population crashes and only the cysts remain.

These thick walled cysts can survive for up to 5 years in the mud of dried up salt lakes. The cysts can be transported long distances attached to feet of birds.

Britton & Johnson (1987) showed a decrease in aquatic invertebrate diversity with increasing salinity. Changes in invertebrate diversity during the summer were found to be stepwise and occurred with changes in the ionic composition of the water. These changes were due first to the precipitation of carbonates and later when gypsum ($CaSO_4$) was precipitated.

Within the salines *Artemia* occurs in etangs with a salinity range 70-320gl^{-1} NaCl (Britton and Johnson 1987), and is an important food of flamingos. Maximum densities of the *Artemia* occur in etangs between 150-250gl^{-1} where they constitute almost the only prey available. In these etangs *Artemia* can reach densities of 16,000 individuals m^{-2}. It is in these etangs, in the east of the salt works, that the greatest number of flamingos can be found. Above 300gl^{-1} the numbers of *Artemia* decline sharply.

It has been assumed in this study that the ecology of the salines described by Britton and Johnson (1987) has remained the same. There has been little alteration in the management of the salines to produce salt since 1986; thus there should have been little change.

Artemia are poor swimmers and during bouts of high wind they may be carried downwind with the water or move to deeper water for stability.

3 AIMS.

The study consisted of four parts.

i) To describe the use of the salines by flamingos during the nesting period.

ii) To investigate the influence of wind on the numbers, distribution and feeding of flamingos within the salines.

iii) To investigate whether differences occur between the times for which male and female flamingos are away from the nest.

iv) To investigate the influence of wind on the time male and female flamingos were off the nest during the breeding season. It was assumed that time off the nest was equivalent to the time required by the birds to obtain sufficient food to be able to then take over incubation.

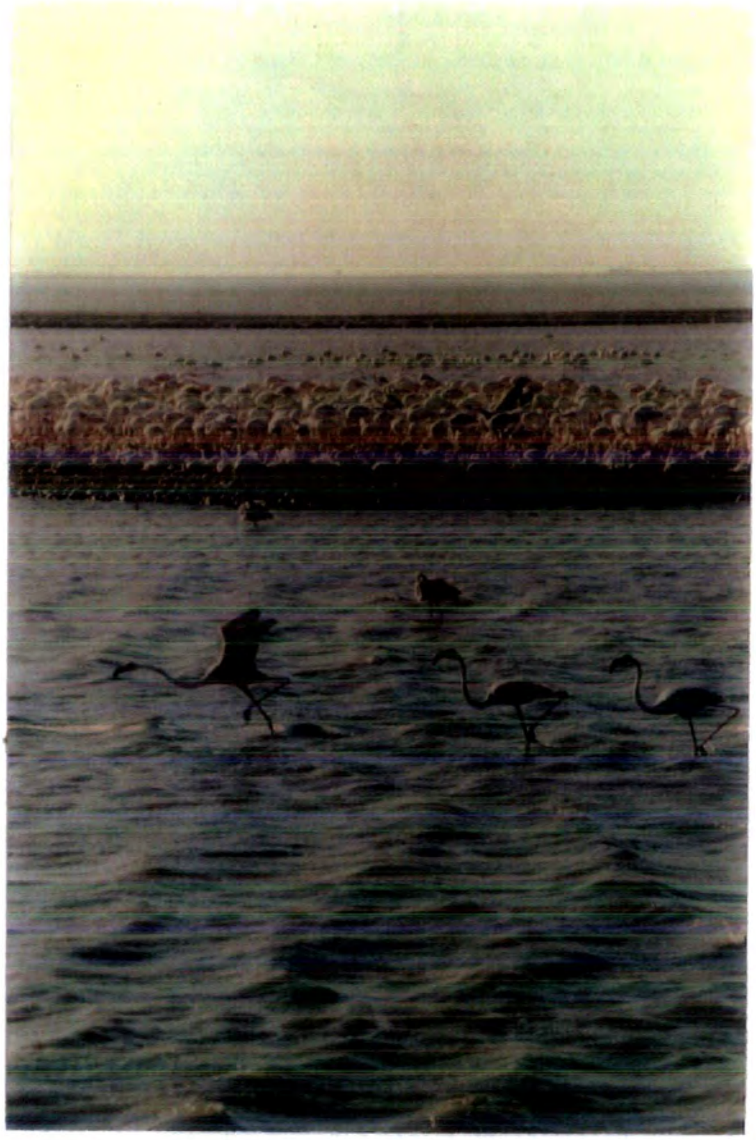


Plate 3. Greater flamingo taking off from infront of the breeding island situated in Fangassier 1.

4.0 METHODS.

The field work for this project was carried out between the 14th April and 12th July 1991 with in the salines of Salin de Giraud, Camargue, France.

4.1. SALINES.

4.1.2 Effect of wind on the distribution and feeding of flamingos.

A route through the salines was established which encompassed 63 etangs. These etangs held water which ranged from the least to the greatest concentration of salt. Tours of the salines following the same route were completed on, 2/5, 6/5, 10/5, 14/5, 16/5, 22/5, 4/6, 11/6, 18/6, 28/6 and 10/7.

An was attempt was made to start the tours of the salines at the same time after dawn. Although not precisely adhered to, in general each etang was surveyed within the same number of hours after dawn on each date.

To assess the effect of wind on the distribution of flamingos within an etang, each etang was divided into an upwind half and a downwind half with respect to the wind direction (fig 5). Thus, this axis rotated as the wind direction changed. This enabled an assessment of effect of wind velocity, regardless of the wind direction.

At each etang the following variables relating to the flamingos were recorded.

Number of flamingos in the upwind half of the etang.
Number of flamingos in the downwind half of the etang.
Total number of flamingos.
Percentage flamingos feeding (across the whole etang).
Depth of water in which flamingos stood (measured by 1/5's of the leg).
Distance to nearest form of shelter (island or dyke) measured to the nearest 10m upto 100m away, and to the nearest 100m there after.

The uniform depth of the etangs and the manner in which flamingos generally formed one large group within each etang meant recording details of the position, depth and distance were straight forward. In cases that there were several groups within close proximity (ie.<200m), measurements were taken from the middle area between all the groups (see fig 6). Groups which were well separated (>200m apart) were recorded as individual groups. Lone individuals were normally ill or injured and were disregarded (Johnson 1983).

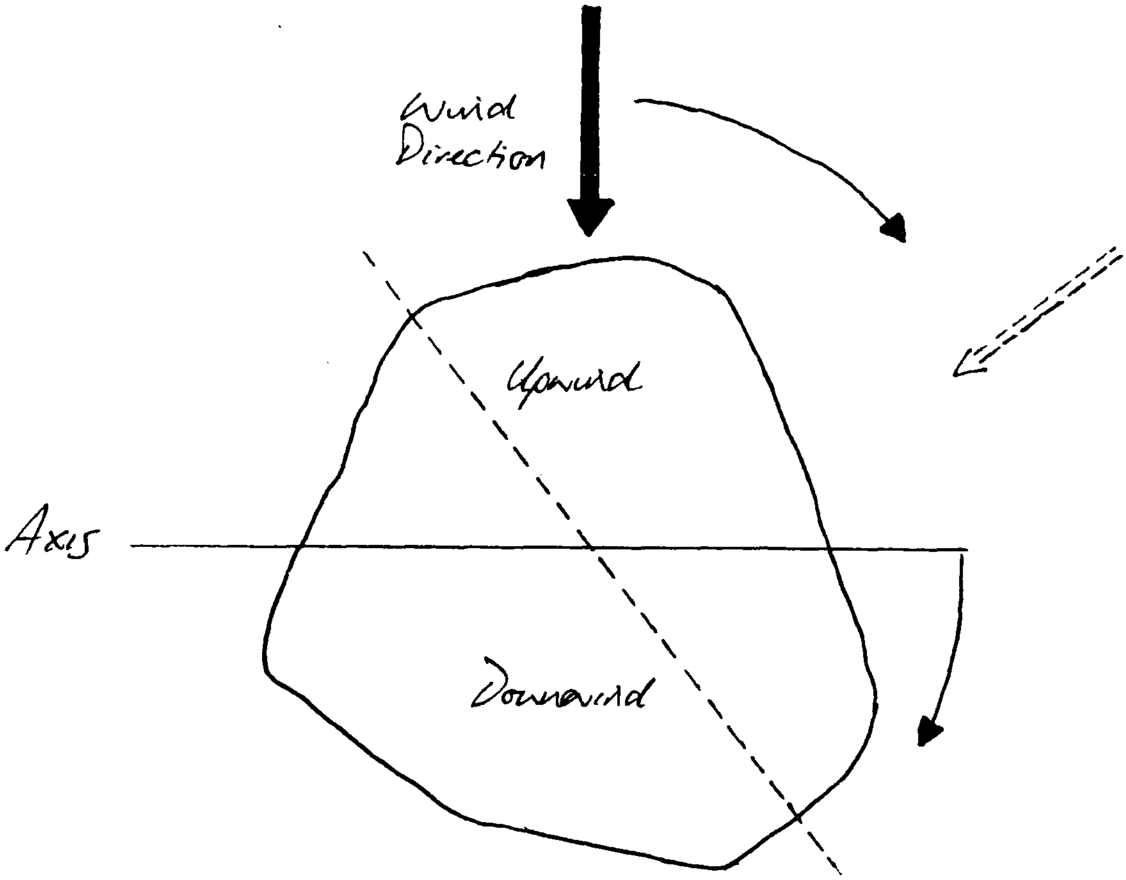


Figure 5. A diagram illustrating how individual etangs were divided into an upwind and a downwind halves with respect to the wind direction. The orientation of this axis rotated was the wind direction changed.

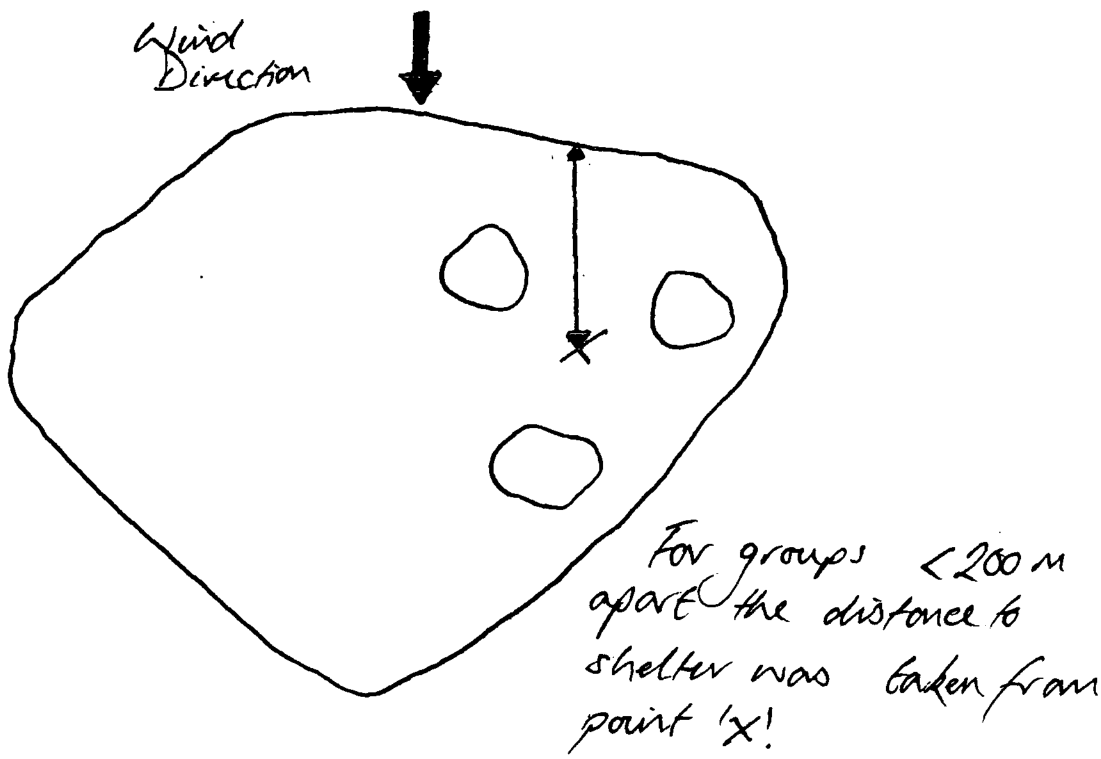


Figure 6. A diagram illustrating how the value for the mean distance to the nearest form of shelter was taken from separate flocks of flamingos in close proximity (less than 200m from each other).

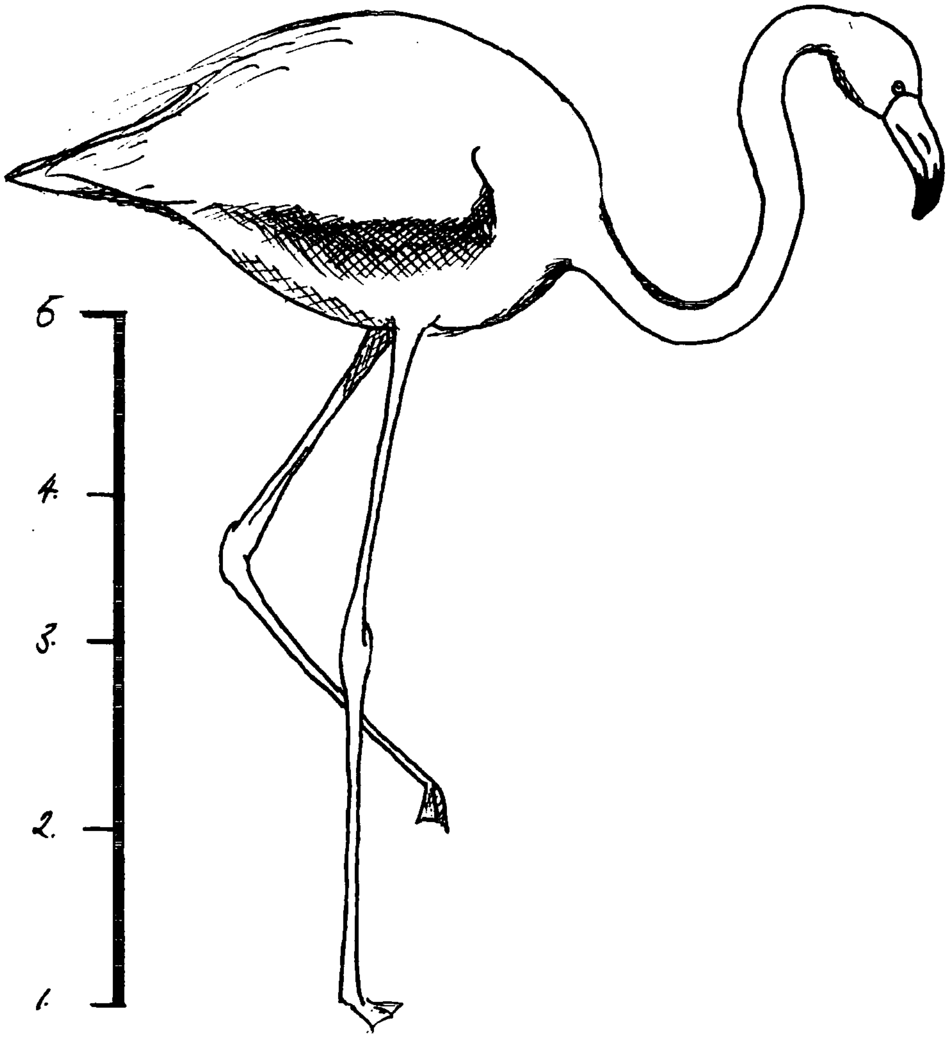


Figure 18. Diagram of a flamingo showing the division of the leg into 1/5's. These divisions were used to gauge the depth of water in which flamingos were stood.

Environmental variables for each etang were noted. These were.

The conductivity of the water on each visit.
The temperature of the water.
Bottom type (sand, organic ooze, gypsum, salt)
Whether algal mat was present.

The position of the flocks of flamingos within each etang were mapped on a diagram of the salines.

At eleven standard points within the saltworks (fig 3) the wind direction and velocity was measured at chest height using a hand held aneometer. Care was taken not to obstruct the flow of wind. This provided a mean wind velocity for the day. Values for the wind direction and gust velocity were taken from the meteorological station at the Tour du Valat.

4.1.3 Timing of feeding activity.

To gain an insight into the timing of feeding activity, a 24 hour survey was performed (5-6th July) on the flamingos in the Basse de Cinq Cent Francs and part of Esquin 7 (Fig 3). The low magnification of the light intensifiers (x4) limited the range over which observations could be taken, but effective observations over the whole area could be made from the road. The light intensifiers relied on a clear moonlit night and the lights from the Fos petrochemical works on the opposite side of the Rhone.

The total number of flamingos seen at 15-30 minute intervals throughout the 24 hour period, and the number feeding in both etangs were noted. Feeding was defined as a flamingo holding its head down with the beak either partially or totally submerged. Counts were taken by day every quarter of an hour (Altmann 1974) but every half hour during the night as complete counts took longer then as I had to move around the etangs when using the light intensifiers.

4.1.4 Movements of flamingos into and out of etangs.

To assess the change in numbers of flamingos in etangs between night and day the numbers of flamingos in seven etangs were recorded, starting an hour after dusk and again an hour after dawn on the 7-8th July. The light intensifiers limited the night counts to smaller etangs in the east of the salt works.

4.1.5 Wave propagation.

Measurements of the water depth and wave amplitude were taken every 100m during a strong Mistral on 28/06/'91 along the etang Pebre which axis lies N.N.W. to assess the development of waves.

A pole marked in 5cm graduations was placed up right to the bottom of the etang. The amplitude of the wave was measured to the nearest 5cm. from this pole by recording the heights of the peak and trough of the waves. The depth of water was taken as the mid point of the wave amplitude.

4.2 FANGASSIER TOWER.

4.2.1 Length of time individuals are away from the nest.

One aspect of the work in the Fangassier tower (plate 4) concerned monitoring the time individuals were way from the nest to establish the division of labour between males and females in incubating the egg and chick.

Thirty three couples, where one or both individuals carried a Darvic ring were monitored at various times from 2/4 to 26/6/91. Beak patterns were also employed to identify individuals. Observations started at first light and the nests were monitored every hour throughout the day until the light failed.

The sex of the individual birds was determined by body size and from breeding records of previous years at the colony.

Only complete shifts were considered. If the change over in partners occured during the night then the mean time between the two consecutive observations was taken as the time of the change over, in order not to bias the shift length of either partner. Shifts during two days on either side of egg laying and the egg hatching were ignored as the partners frequently swapped (see fig. 8).

Plate 4. The tower hide 70m from the breeding island in Fangassier 1. The floating hide in the fore ground allows observers to enter and leave the tower without disturbing the birds.

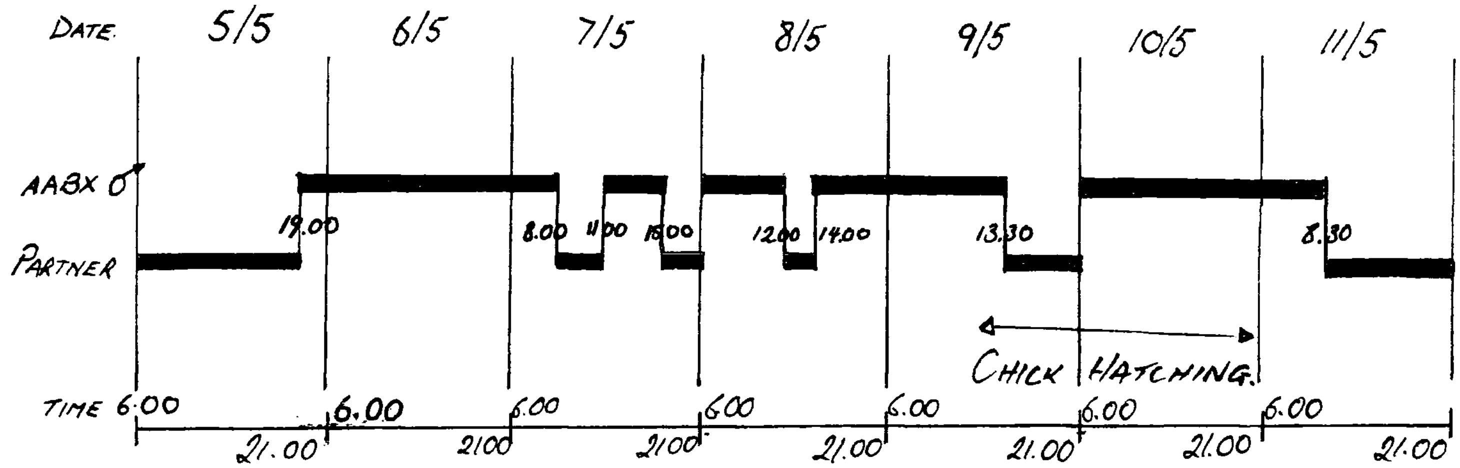


Figure 8. illusrates the frequent swapping of partners before and after the egg is laid and again when it hatches. The shifts two days either side of the egg laying and hatching were disregarded.

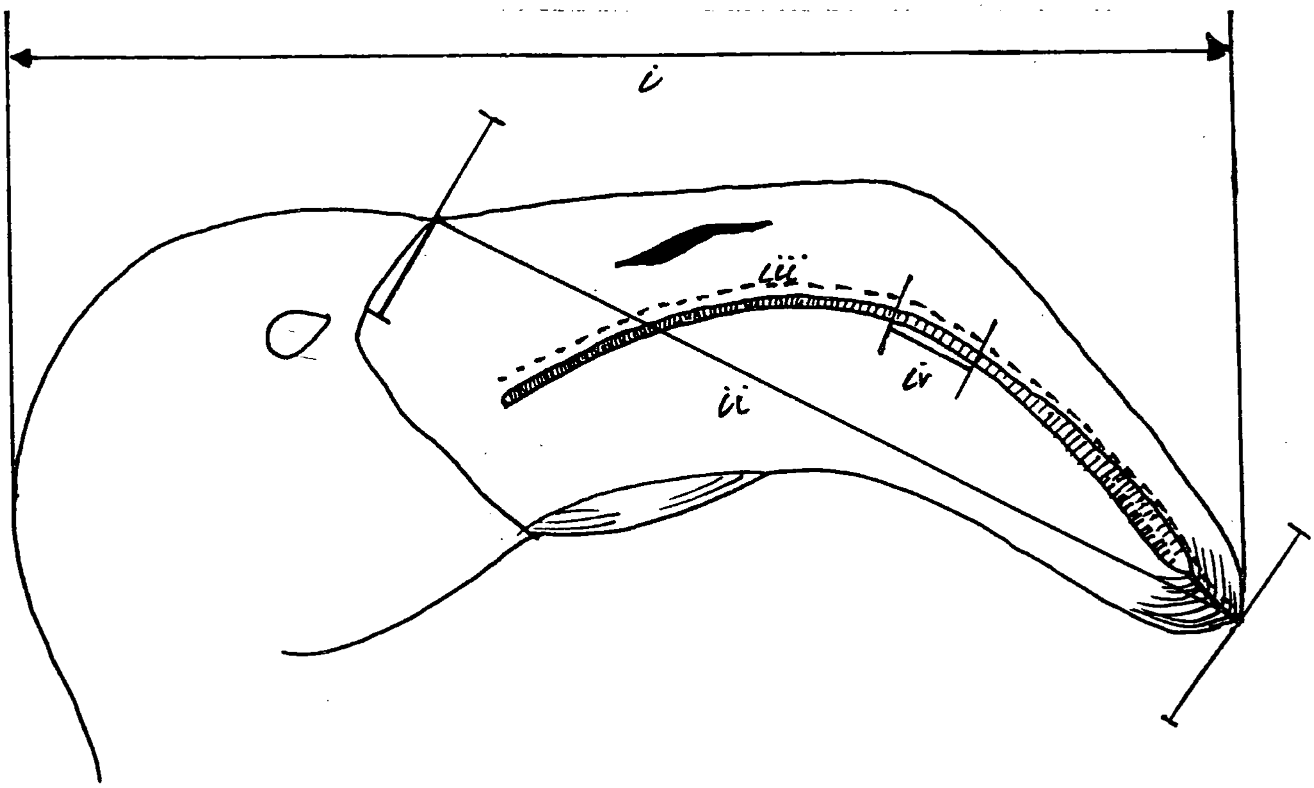


Figure 7. The measurements taken from a flamingo beak.

i) Length of skull and beak.
ii) Length of beak.
iii) Perimeter of beak.
iv) Length of 10 lamellae.

4.2.2 Beak measurements.

Seven male and four female adult flamingos (sexed by tarsus measurements) were measured to compare whether there was any difference in the size of the beaks of either sex.

Dimensions measured were (see fig. 7):
- the length of the head;
- the length of the beak;
- the perimeter of the beak gape;
- the length of the 10 excluders after the bend in the beak.

The excluders at this position were the widest spaced, and place a limit on the maximum size of prey that are retained during feeding.

4.3 ANALYSIS OF DATA.

4.3.1 Salines.

The numbers of flamingos in Fangassier I and II were not included in the total numbers. This was because of birds in the water around the breeding colonies on the island and dyke were generally not feeding. These birds were involved in diplays, washing and sleeping. By early July many birds had started moulting. Many of these birds lost the ability to fly and remained close to the colony.

The total number of flamingos within the salines was correlated (Spearmans' rank) against the mean wind velocity for the day.

To quantify the use of the salines by flamingos a **CANOCO** programme (**CANO**nical **C**ommunity **O**rdination) was performed. This program uses a combination of ordination and multiple regression to produce an ordination diagram of the samples, species and environmental data (Ter Braak 1988), and was used to describe the use of the salines by flamingos with respect to the salinity and area of each etang. This illustrates how samples vairy with the environment. The ordination diagram places similar sites close together and dissimilar sites far apart.
Data for CANOCO is normally entered in a matrix in the format of:

SPECIES (and their abundance)
S
A
M
P
L
E

For the purpose of this analysis a data matrix in the format of:

SAMPLES (Total N^{O} of flamingos in each etang)
D
A
Y
S

was used. This classified the use of individual etangs by the numbers of flamingos counted on each day.

The upper limit on the number of environmental variables (conductivity and area) in CANOCO is 48. This meant that only 48 etangs could be included in the analysis. The etangs included in the data set covered the whole range of salinities included on the study route.

4.3.2 The effects of wind on the distribution of flamingos.

To investigate the influence of wind on the feeding distribution and behaviour of the flamingos within an etang, two further CANOCO analyses were performed, on the days of least wind and strongest wind. Details of the flamingos included the following

- i) the numbers the upwind half and,
- ii) the numbers in the down wind half of the etang,
- iii) the total numbers of flamingos in each etang,
- iv) the percentage of the total numbers of flamingos feeding,
- iv) depth at which the flamingos fed,
- v) distance to the nearest form of shelter.

These were correlated against the environmental variables of conductivity, area of etang and average wind velocity. Other environmental variables (eg bottom status) were correlated with salinity, and so were encompassed by the measure of conductivity. The wide variation in water temperature with in a day meant it had little meaning within the analysis.

Further Spearmans' rank correlations were performed between the mean wind velocity and the means for the details of flamingos described above. This aimed to establish the overall influence of the wind on the use of the salines by flamingos.

4.3.3 Movements of flamingos.

The pairs counts taken after dusk and dawn were tested by a Mann Whitney U test, to examine whether there was a significant change in numbers between day and night.

4.3.4 Time away from the nest.

The times spent away from the nest by male and by female flamingos were compared for differences by Mann Whitney U tests. The effect of the wind on the time away from the nest was also investigated by Spearmans' rank correlation.

4.3.5 Beak measurements.

The dimensions recorded were tested for the significance of any differences between the sexes by Mann Whitney U tests.

5.0 RESULTS.

5.1 DISTRIBUTION OF FLAMINGOS WITHIN THE SALINES.

The mean number of flamingos in each etang between April-July 1991 was plotted against the mean conductivity of the water within the etang during this time (fig 10). This figure shows the sharp peak in the mean numbers of flamingos in etangs with water between 90-110 milli siemens conductivity.

Fig 13 is an ordination plot from CANOCO of the numbers of flamingos within individual etangs against the conductivity of the water contained within these etangs each sample day. Ordination clusters together sites that are similar in abundance of flamingos and places dissimilar sites far apart.

Axis 1 relates to the numbers of flamingos in individual etangs and axis 2 follows to the increasing salt content of the etangs.

There are 4 main clusters of etangs outlined on fig 11.

Cluster 1. This group consists of both low (50-90ms) and high (131-150ms) salinity etangs which are used by flamingos to some extent during the early breeding season.

Cluster 2. The etangs in this group hold water of very high salinity (conductivity=134-150ms). It is very rare to find flamingos in these etangs, but birds are recorded occasionally in these sites.

Cluster 3. This is a group of high salinity etangs (110-150ms conductivity) which are greatly used by flamingos. Within this cluster are lower salinity etangs Galabert 2 and Enforces de la Vignole. These etangs regularly contain large numbers of flamingos, but this is probably due to the closeness of these site to the breeding colony in Fangassier 1.

Cluster 4. These medium strong salinity etangs are greatly used by flamingos. The conductivity of the etangs in this cluster ranges from 84-120ms.

The etangs in clusters 3 and 4 are etangs in which *Artemia* is most abundant. The cluster of etangs in group 4 constitute the peak in fig 10.

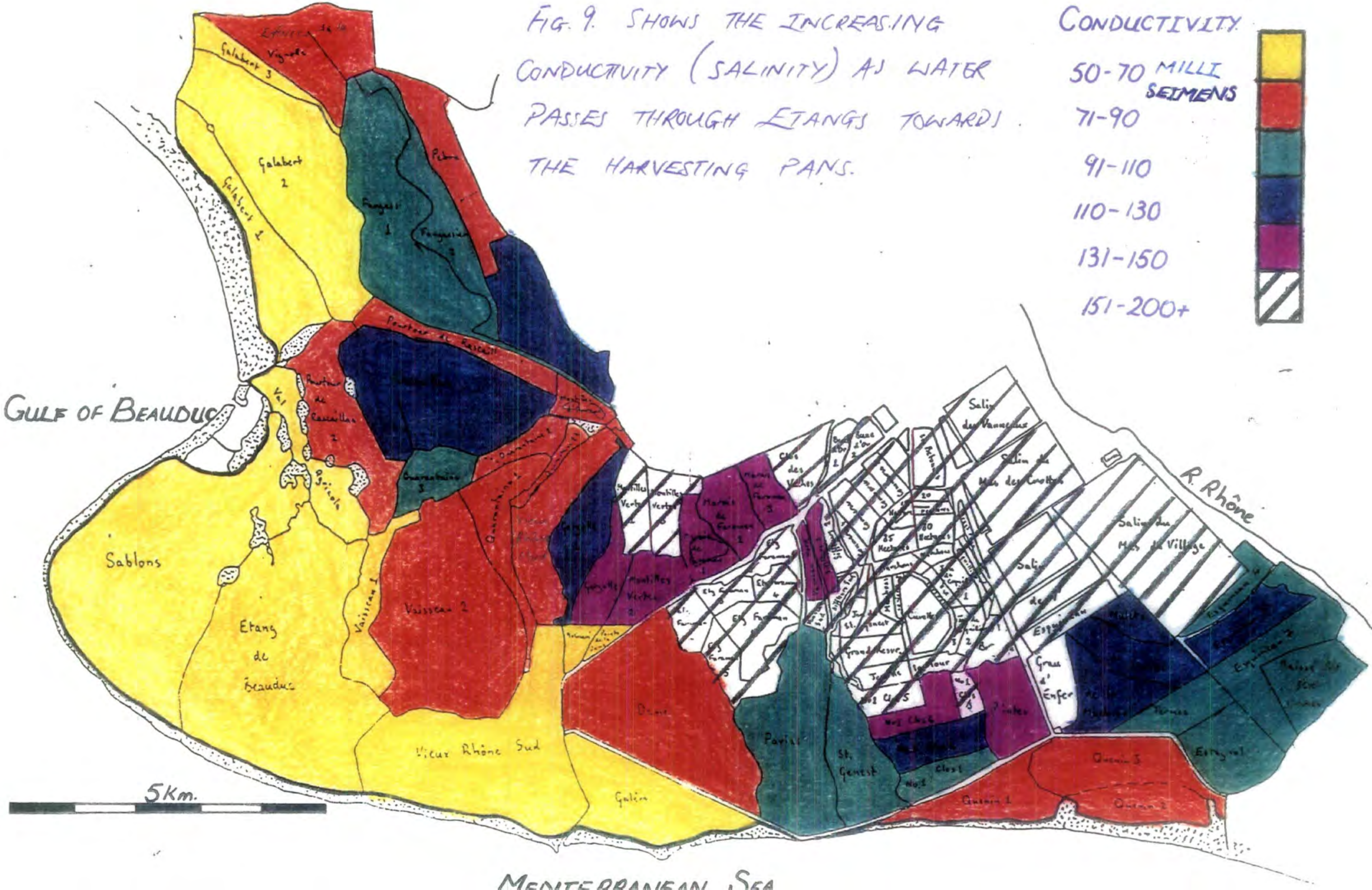


FIG. 9. SHOWS THE INCREASING CONDUCTIVITY (SALINITY) AS WATER PASSES THROUGH ETANGS TOWARDS THE HARVESTING PANS.

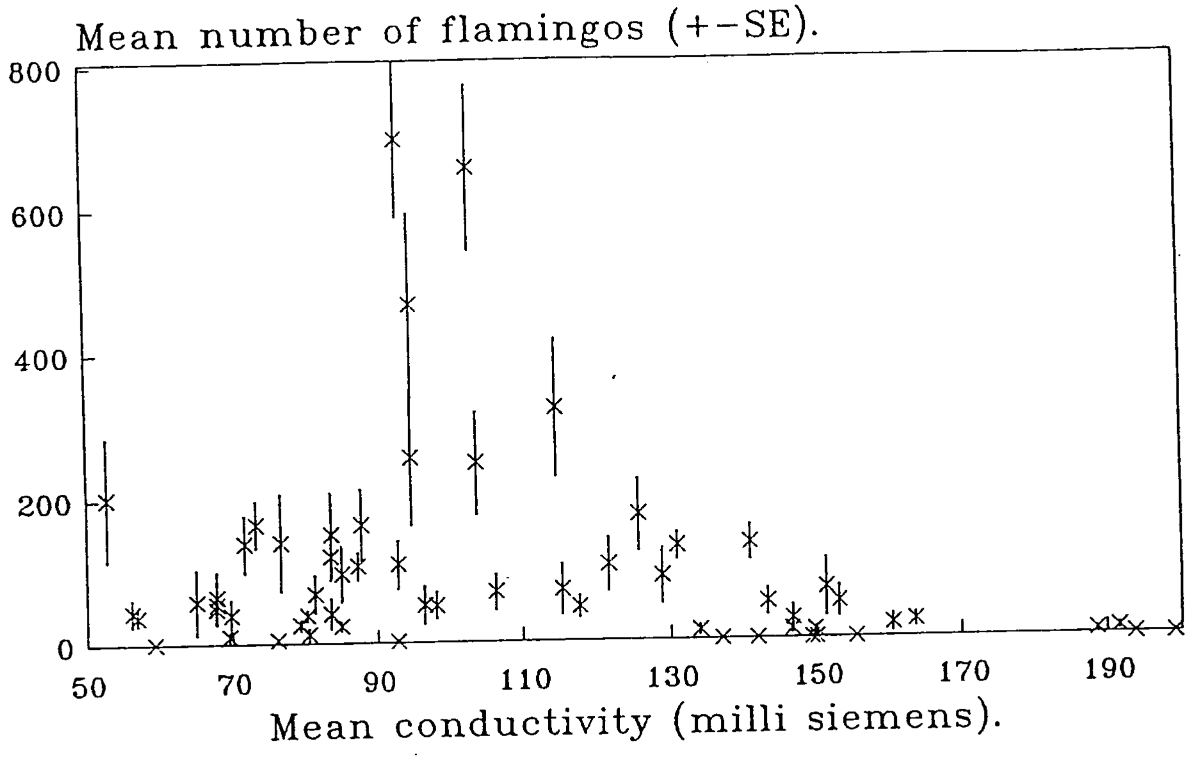


Figure 10. Plot of the mean number of flamingos in individual etangs (+- S.E.) during the period 12/4/92-12/7/91. against the mean conductivity (milli siemens) of the water within the etang.

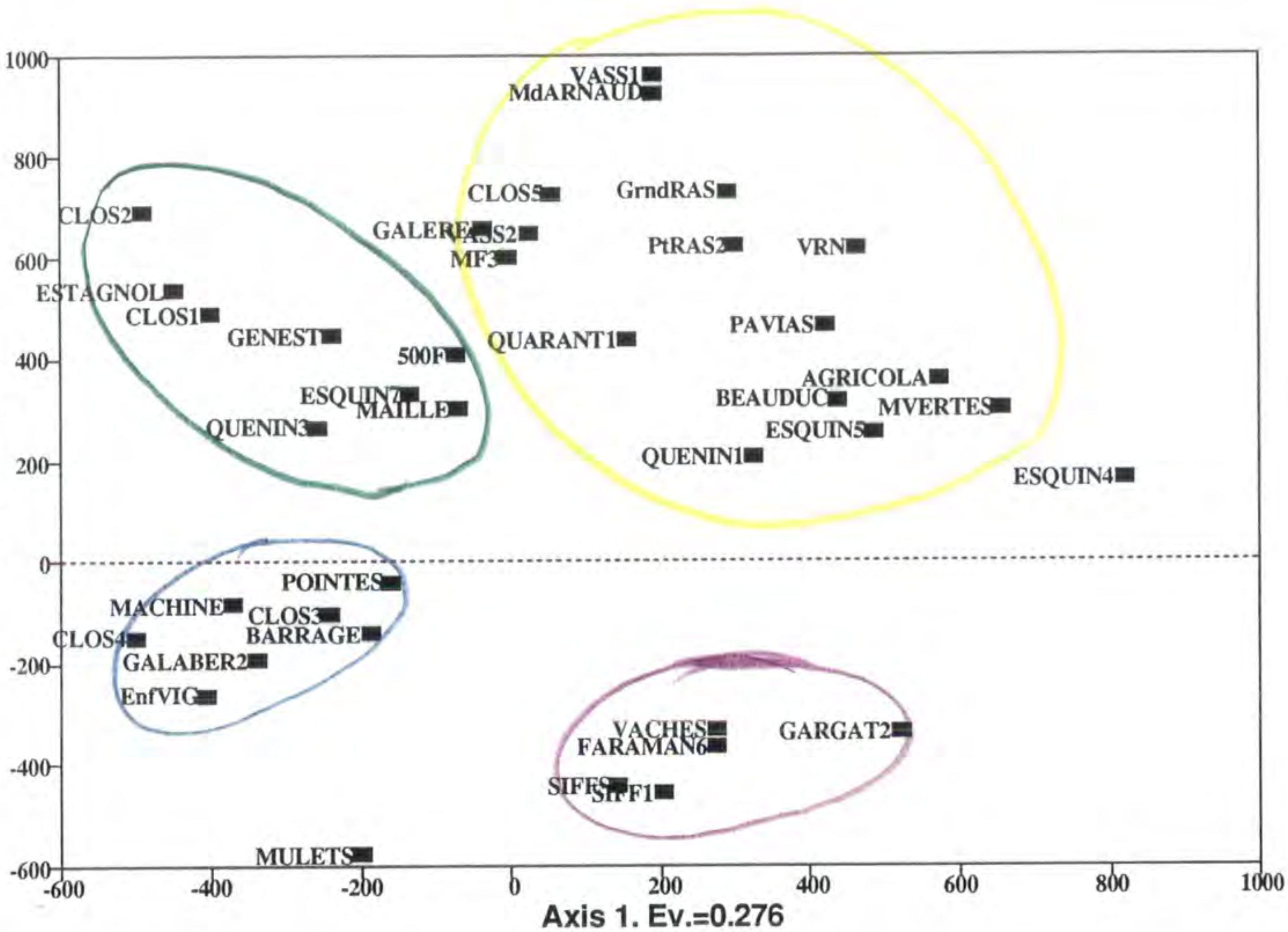


Figure 11. Ordination plot from CANOCO of the total numbers of flamingos on each survey data against the conductivity of the water contained within the etang. The four clusters outlines are described in the text.

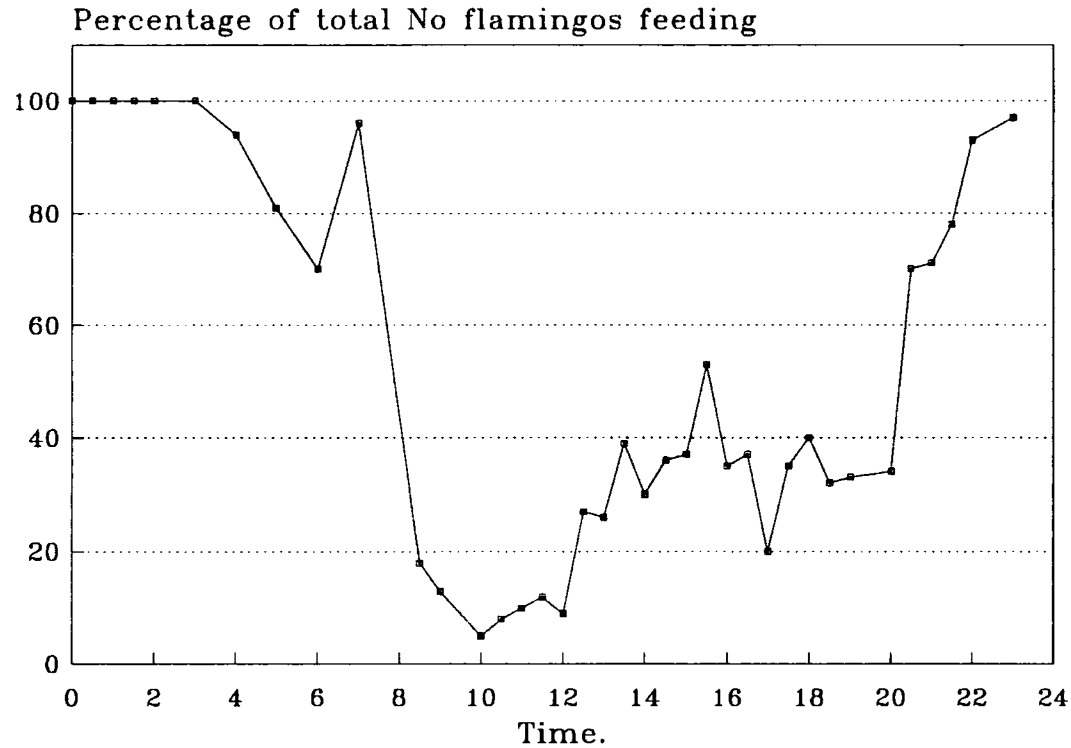


Figure 12. A graph of the percentage of the total numbers of flamingos feeding during a 24 hour watch on the 5-6/7/91. The survey was carried out on the Baisse de Cinq Cent Francs and part of Esquineau 7. Numbers varied between 207 and 890.

5.2 EFFECTS OF WIND ON FLAMINGOS WITHIN THE SALINES.

5.2.1 Description of the ordination plots.

Figs 14 and 15 are ordination plots from a CANOCO of the distribution of flamingos within the etangs on two separate days, One day with low velocity wind and the other with high velocity Mistral (10/5 and 28/6 respectively). The environmental variables are represented by biplot arrows. The arrows represent the direction of maximum variation in the value of the environmental variable. The length of the arrows serves as a measure of the importance of the environmental variable.

5.2.2 Low velocity wind (fig 14).

The cluster in fig 14 of the numbers of flamingos upwind, downwind and total numbers illustrates that flamingos were distributed across the whole etang. The point for percentage feeding is included in this group and reflects to the fact that a proportion of flamingos are feeding over the whole of the etang.

The value for distance to nearest shelter on fig 14 is large in comparison with fig 15 but not associated with any other variables. This reinforces the suggestion that the flamingos have free range over the etang. Flamingos stood in shallow water during mild winds.

5.2.3 High velocity wind (fig 15).

The grouping of the points for the numbers of flamingos upwind and the total numbers of flamingos in Fig 15 indicate that almost all the flamingos have collected in the more sheltered upwind half of the etang. The numbers down wind are very different to both these values and downwind is a lone point.

The % of flamingos feeding, depth of water at which flamingos are stood and distance to shelter are grouped together but separated from the upwind point. This illustrates that for flamingos to feed during a Mistral they have to move partially away from shelter to deep water, but only to a relatively short distance compared to the range during a mild wind.

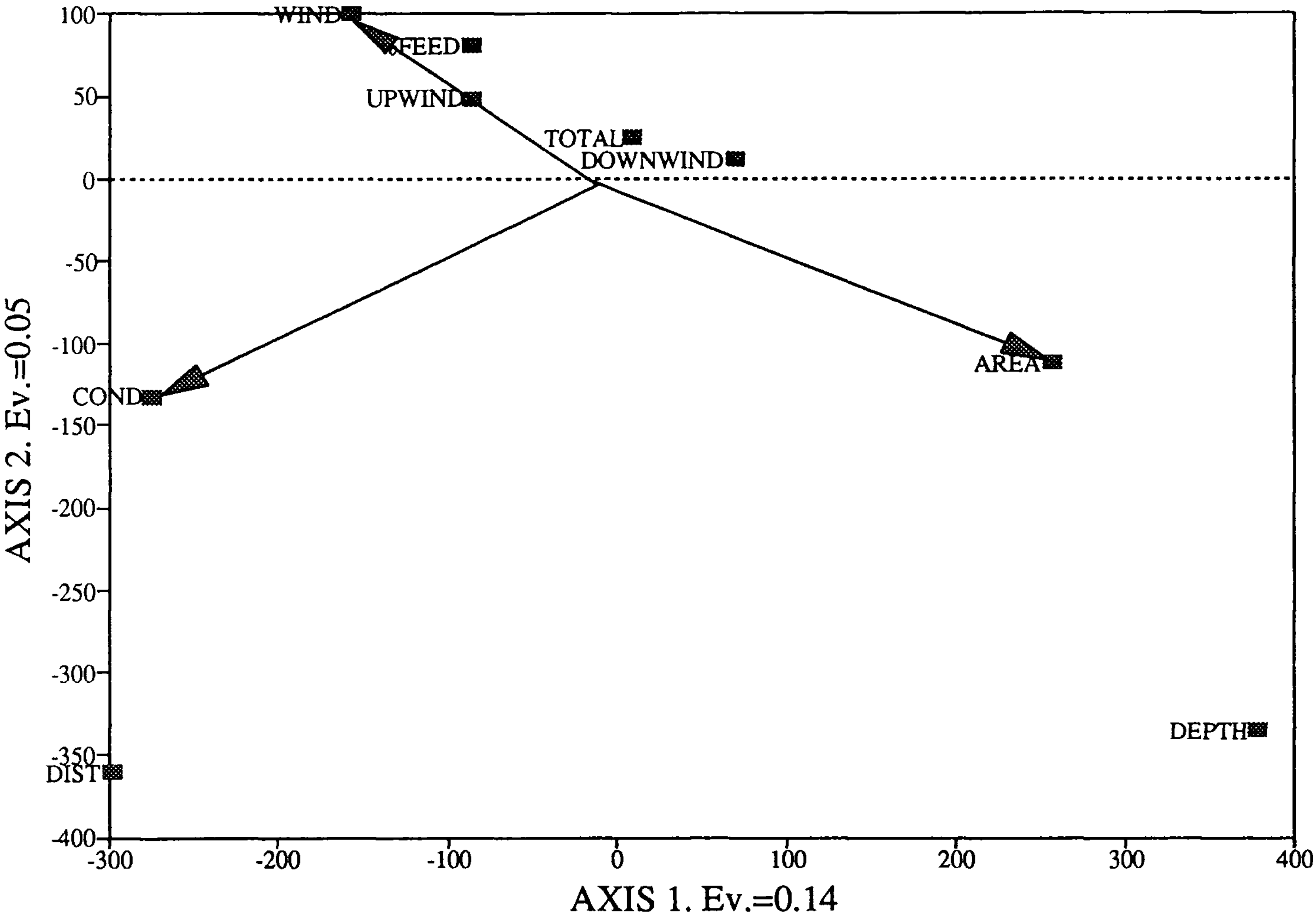


Figure 14. Ordination plot from CANOCO of the distribution and feeding of flamingos within an etang during a day of mild wind (10/5/91, mean wind velocity=7.3kmhr^{-1})
Environmental variables used were area of the etang, conductivity of the water within each etang and the mean wind velocity for the day.

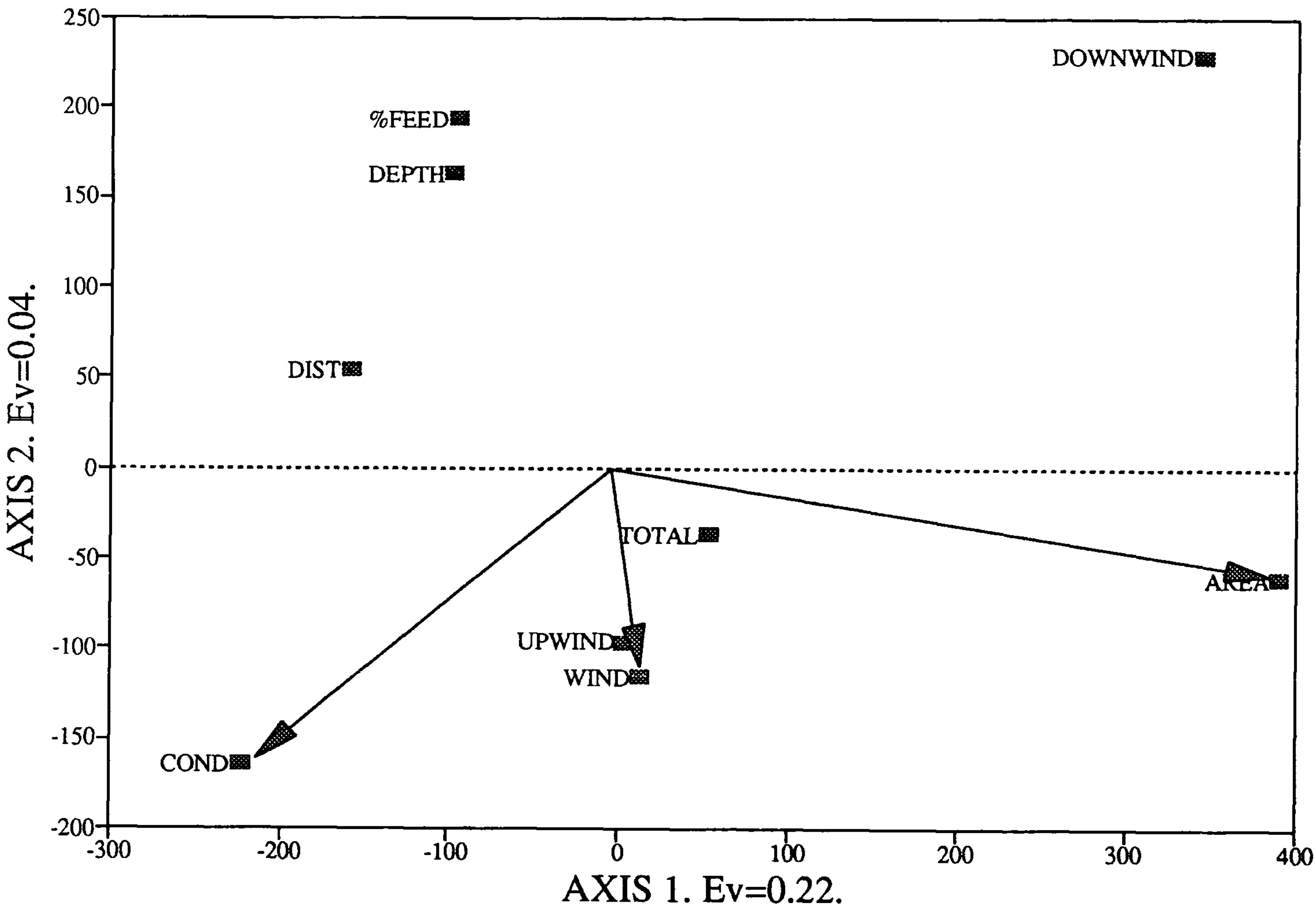


Figure 15. Ordination plot from CANOCO of the distribution and feeding of flamingos within an etang during a day of strong wind (28/6/91, mean wind velocity 27.7kmhr^{-1}).
Environmental variables were area of the etang, conductivity of the water within the etang and the mean wind velocity for the day.

Survey date	Total Flamingos	Ave Wind KmHr-1	%Feeding	Ave Dist to shelter	Standing depth
2/5	3999+-406	27.2	37	100	3.7
10/5	6518	7.3	37	160	2.8
14/5	7939	13.7	55	430	3.2
16/5	5435	22.9	54	133	3.1
22/5	7025	13.7	54	320	3.1
4/6	3975	25.9	52	220	3.5
11/6	5399	21.0	60	140	2.95
18/6	6033	19.8	70	270	3.5
28/6	4571	27.7	54	112	3.3
10/7	6990	15.3	57	480	2.9

Table 1 Tabulates the total number of flamingos, the average wind velocity, % feeding, average distance to shelter and average depth of water in which flamingos were standing on the days on which the salines were sampled.

	WIND VELOCITY r	P	df
TOTAL Nos	-0.865	0.01	9
% FEEDING	0.154	NS	9
DEPTH	0.635	0.05	9
DISTANCE	-0.705	0.05	9

Table 2. Spearmans' rank correlations between wind velocity and the 4 other variables tabulated in table 1

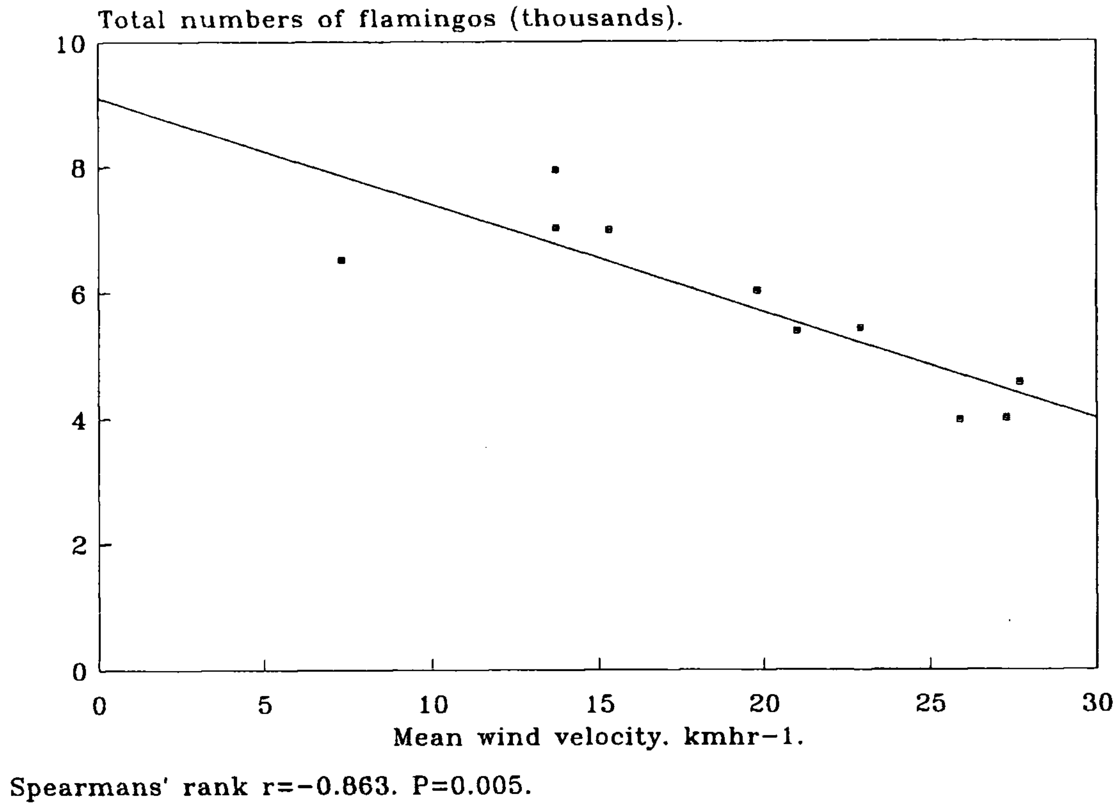


Figure 13. A correlation of the total numbers of flamingos on the survey days against the mean wind velocity for the day.

There was a significant negative correlation between the mean wind velocity and the total numbers of flamingos recorded within the salines (Spearmans' rank test r=-0.865 P=0.001 DF=9).

There is a significant relationship between the mean wind velocity and the depth of water in which flamingos are stood. (Fig 17) (Spearmans' rank test r=0.635, P=0.05)

There is a significant negative correlation between the mean wind velocity and the mean distance to shelter (Spearmans' rank correlation r=-0.705, P=0.05). (Fig 16).

5.2.4 Comparision of the numbers on the 10/5 and 28/6.

Data summarising the numbers and distribution of flamingos on the 10/5 and 28/6 are listed in appendix 1 and 2.

There was a significant difference in the total numbers of flamingos found in the salines on the two days (Mann-Whitney U test P=0.03, DF=59). There was a significant difference in the numbers of flamingos recorded in the downwind half of the etangs on the two days (P=0.0003, DF=59), but there was no significant difference in the numbers in the upwind half (Mann-Whitney U test P=0.08, DF=59 NS)

5.3 DAWN DUSK COUNTS.

There was no significant difference in the numbers of flamingos counted in the etangs during the night and day (Mann Whitney U test P=0.898 DF=6).

ETANG	AFTER DUSK	AFTER DAWN
500F	243	275
ESQ 7	241	225
MAILLE	109	168
POINTES	173	405
CLOS1	165	124
ESQUINEAU 4	103	43
ESQUINEAU 5	59	22
TOTAL	1093	1262

Table 3. The total numbers of flamingos in a series of etangs counted an hour after dusk and dawn on the 7-8/7/'91.

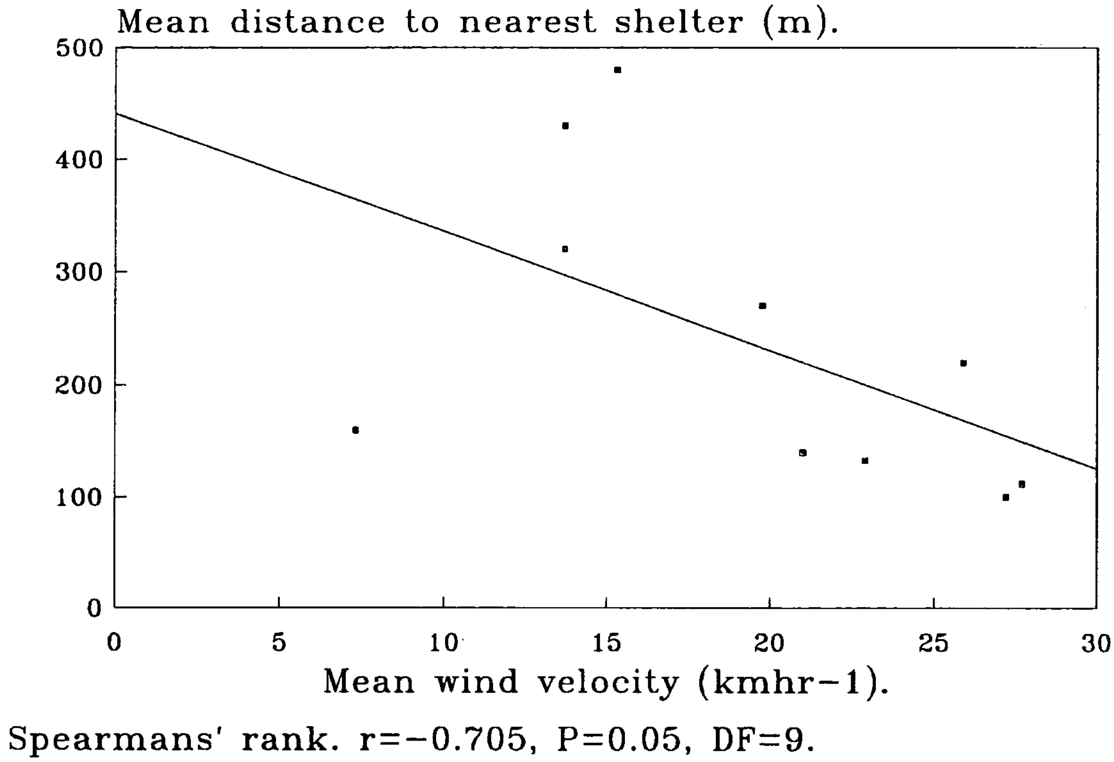
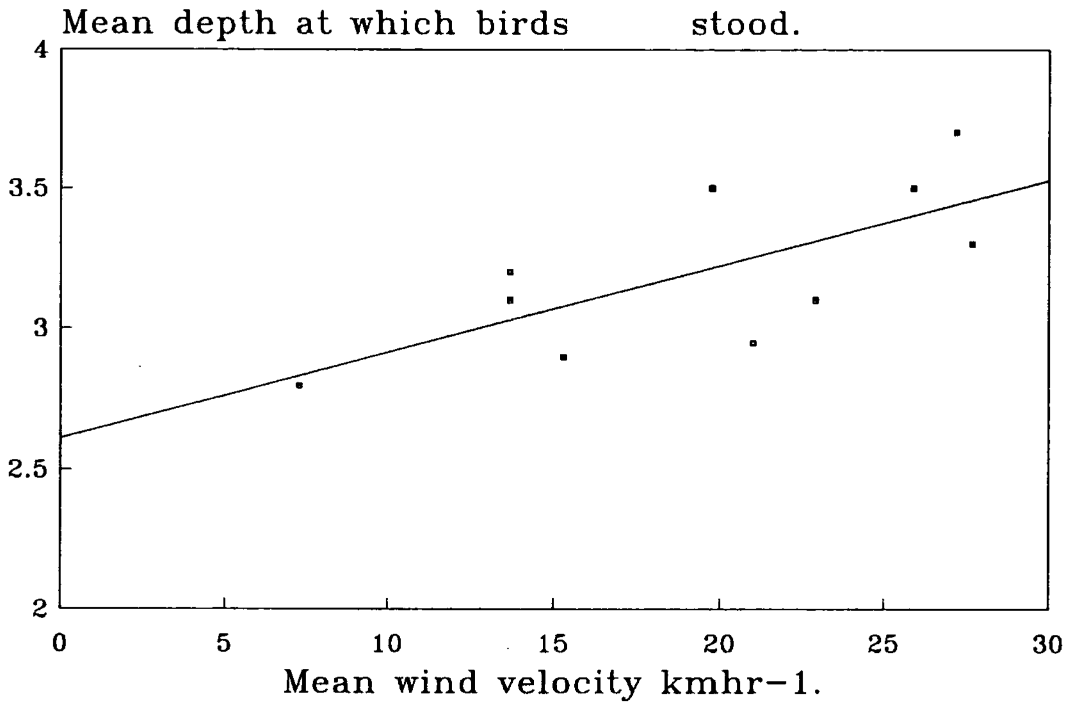


Figure 16. Correlation between the mean distance to shelter of flocks of flamingos and the mean wind velocity for the day.



Spearmans' rank. r=0.635, P=0.05, DF=9.

Figure 17. Correlation between the mean depth of water that flamingos were stood in and the mean wind velocity for the day.
The depth of water was measured in 1/5's of the leg of large male flamingos which were identified by their size (figure 18).

5.4 BEAK MEASUREMENTS.

Four female and seven male flamingo heads were available during the field season. Various dimensions of the head and beak were taken from these (fig 7) to assess whether there was a significant difference in the size of the beaks of either sex.

MALES				
TARSUS LENGTH mm	HEAD LENGTH mm	BEAK LENGTH mm	BILL PERIMETER	LENGTH OF 10 LAMELLAE
323	17.5	13.15	12.1	1.8
329	17.2	12.78	12.2	1.69
290	16.5	12.83	11.4	1.18
322	17.35	12.96	11.7	1.69
340	17.2	12.87	11.8	1.68
323	16.75	12.88	11.7	1.94
305	16.8	12.92	11.7	1.75
FEMALES				
260	16.4	12.89	11.8	1.19
255	15.6	12.19	10.4	1.35
272	16.1	12.09	10.7	1.19
250	15.65	11.96	10.8	1.49

Table 4. Values for the dimensions measered from the tarsus and beaks of male and female flamingos.

These measurements were tested for significant differences between the sexes by Mann-Whitney U test (table 5). There were significant differences between males and females in the length of the tarsus.

	Probability	SIG/NS
TARSUS	0.01	sig
HEAD	0.01	sig
BEAK	0.07	NS
BEAK PERIMETER	0.089	NS
LENGTH OF 10 LAMELLAE	0.07	NS

Table 5. Probability values and level of significance of the Mann-Whitney U tests between the measurements of dimensions listed of male and female flamingo heads and bills.

5.5 TIME AWAY FROM THE NEST. (Figs 19 and 20).

Data on the time away from the nest was transformed by $\log_{10}$ to approach a normal distribution. Differences in the time away from the nest by males and females was tested by paired t-test.

SEX	N	MEAN ABSENCE (hours)	S.E.	MINIMUM	MAXIMUM
Female	186	27.5	1.05	5.0	127.4
Male	175	23.3	1.05	7.0	105.4

Table 6. Description of the time off the nest for male and female flamingos whilst incubating the egg.

Females spend significantly more time away from the nest than males (paired t-test t=2.58 P=0.01 DF= 359)

5.6 EFFECTS OF WIND ON THE TIME AWAY FROM THE NEST.

Each sex was analysed individully to investigate the effects of wind on the time away from the nest.

The meterologiocal station at the Tour du Valat, provided values for the mean wind velocity for the day (ms^{-1}) and the maximum gust velocity each day (ms^{-1}) during the breeding season. The values for the maximum gust each day was recorded to the nearest meter per second.

The mean time away from the nest was calculated for each class of maximum gust. There was a significant positive correlation between the mean time away from the nest and the maximum gust during this time for both male and female flamingos (Spearmans' rank. Male r=0.487, P=0.05 Female r=0.663, P=0.005) Figs. 21 and 22.

Differences in the time spent away from the nest by male and female flamingos could have been due to differences in gust velocity during the time away from the nest. However, there were no significant differences in the gust strengths during time that male and female flamingos were away from the nest (paired t-test t=1.5, P=0.13, DF=328).

5.7 THE GUST STRENGTH DURING 1984 AND 1985.

Green & Hirons (1985) stated that the incubation shifts were longer in 1984 than 1985. The values for the maximum gust velocity each day in April-July 1984 and 1985 were tested for differences

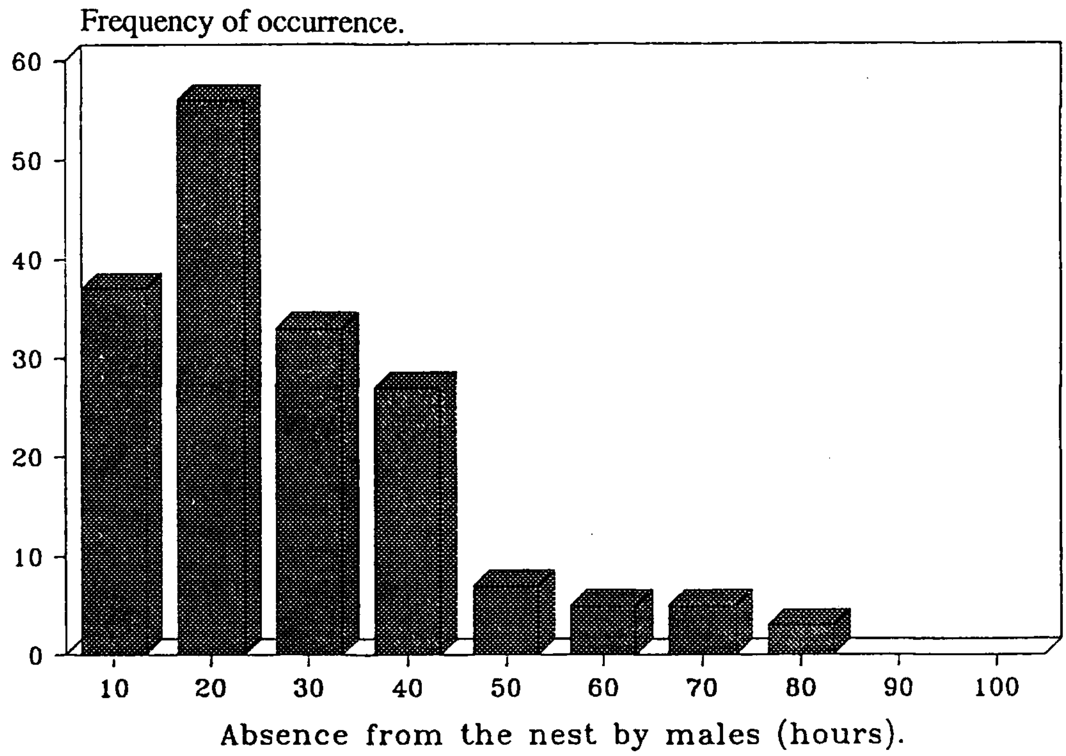


Figure 19. Frequency histogram of the time away from the nest by male breeding flamingos.

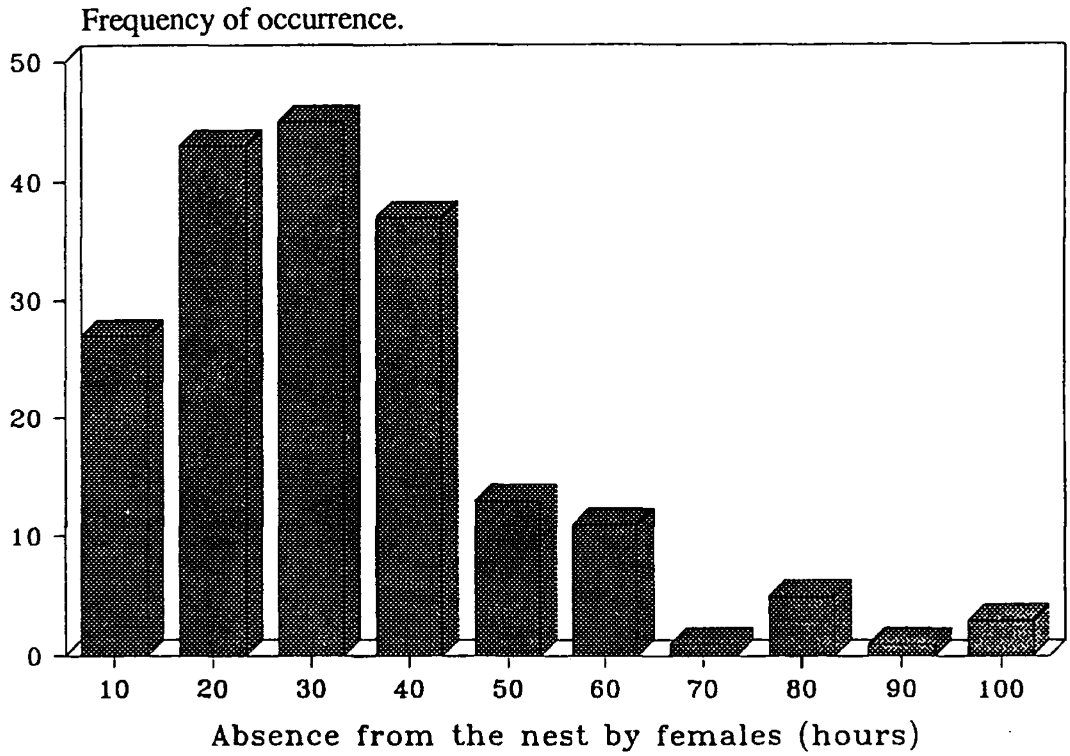


Figure 20. Frequency histogram of the time away from the nest by female breeding flamingos.

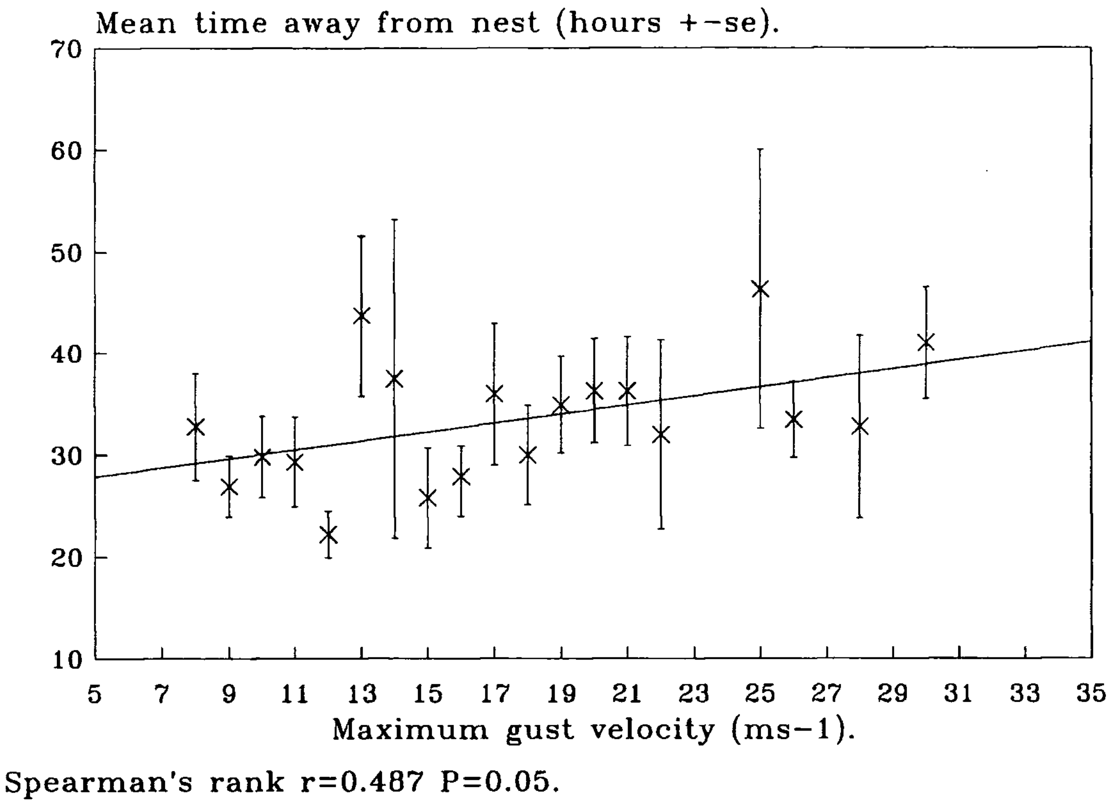
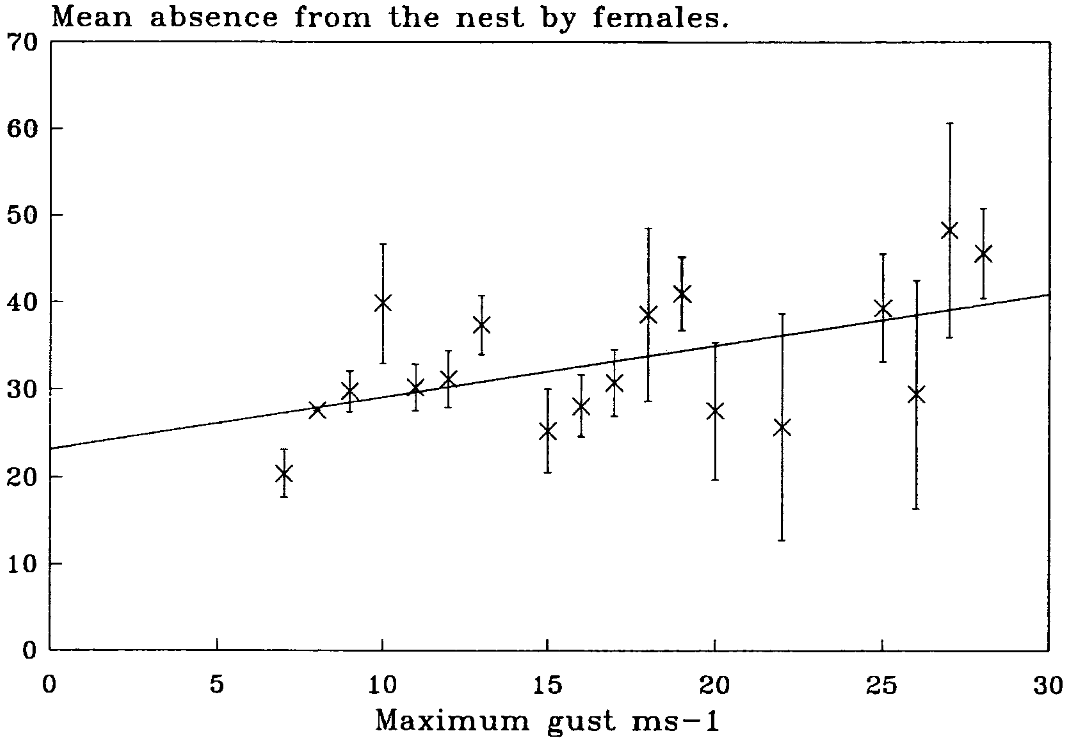


Figure 21. Correlation of the mean absence from the nest by male breeding flamingos against the maximum gust of wind (ms^{-1}) during the time away.



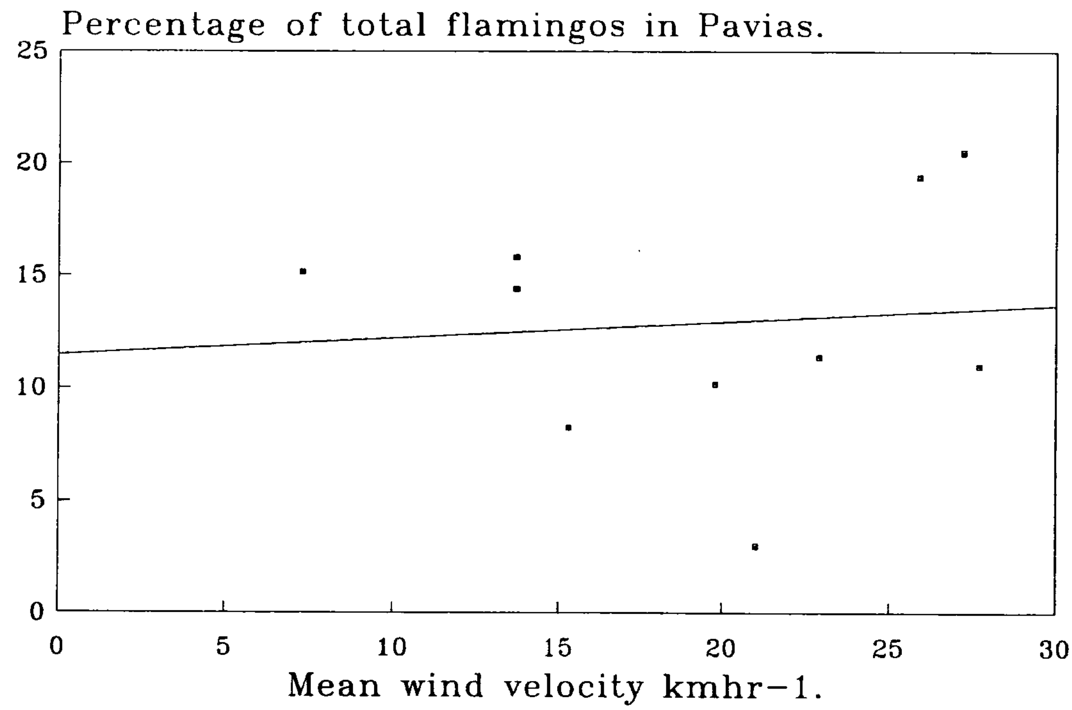
Spearmans' rank r=0.663, P=0.005.

Figure 22. Correlation of the mean absence from the nest by female breeding flamingos against the maximum gust of wind (ms^{-1}) during the time away.

YEAR	N	MEAN GUST	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM
1984	121	13.54	4.689	0.426	6	29
1985	121	12.13	4.4	0.4	5	27

Table 7. Description of the maximum gust strengths during April-July 1984 and 1985.

There were significantly more days of high velocity wind during 1984 than 1985 (Paired t-test t=2.4 P=0.01 DF=240).



r=0.462, not significant at P=0.05.

Figure 23. Correlation between the percentage of the total number of flamingos within Pavias against the mean wind velocity.

6.0 DISCUSSION.

6.1 USE OF THE SALINES BY FLAMINGOS.

It is clear from fig 12 that flamingos feed mostly during the night. Britton *et al.* (1986) were unable to explain night feeding in terms of feeding efficiency but there could be other explanations why flamingos feed at night, such as predator avoidance or thermoregulation. Higher day-time temperatures increase the energy expenditure required for feeding and assimitating food. During the summer it may be energetically advantagous for flamingos to feed during the colder part of the 24 hour cycle and spend the day asleep which demands little energy.

Several workers have stated that the main movements of flamingos occurred at dawn and dusk (Britton *et al.* 1986, Johnson 1983). However in my study, there was no significant difference in the overall numbers of flamingos in the seven etangs monitored during the night and day. The numbers of flamingos within the etangs do change between the two times as birds move in to or out of the area, or move to and from the colony, but overall there is no pattern to these movements.

Previous researchers have described how flamingos favour the moderately high salinity etangs in the east of the salt works (Britton *et al.*). This is confirmed by figs. 1 and 2. Fig. 1 illustrates that flamingos can be found throughout the salines, but the sharp peak in numbers occurring at salinities between 90-110 ms` reflects the narrow band of etangs in which greatest numbers of flamingos are found. It is within these etangs that the brine shrimp *Artemia* is most abundant (Britton & Johnson 1986). During the summer this invertebrate species represents almost the sole food item.

The ordination plot from CANOCO reinforces these trends (fig 11). The four main clusters illustrate that flamingos are found throughout the salines, but the greatest numbers of flamingos occur in the etangs within a conductivity range of 90-110ms. Large numbers of flamingos can also be found in etangs neighbouring fangassier 1 regardless of the salinity of the water.

The movement of saline water towards the harvesting beds has a major influence on the distribution of feeding flamingos. Esquineau 4 was little used, yet it holds water within the salinity range 90-110ms at some times of the year. However, in 1991 this etang remained dry for 2 months of the field season.

My project did not address variations in the diet of the birds during the season. Flamingos may feed from other etangs which provide a particular dietary requirement, or at those times during the season when they hold was a temporary abundance of an alternative food.

6.2 EFFECTS OF WIND ON THE FLAMINGOS WITHIN THE SALINES.

6.2.1 Description of ordination plots.

Both ordination plots (fig 14 and 15) show how the extremes of area and conductivity are avoided. The etangs of greatest area are the lower salinity etangs eg Beauduc. Although they hold a more diverse fauna and flora these etangs have few if any *Artemia*. They are more important as winter feeding grounds (Johnson 1983). The numbers of *Artemia* decline rapidly at salinities above $300gl^{-1}$. Thus, both extremes of salinity are avoided by feeding birds.

The most striking result is the significant negative correlation between the total numbers of flamingos within the salines and the mean wind velocity (fig 13. r_9=-0.856 P=0.01). Reasons for this are discussed below.

6.2.2 Low velocity wind.

Flamingos were recorded in 41 of the 63 etangs included on the route during a day of low wind wind velocity (10/5/91). The mean wind velocity was $7.3kmhr^{-1}$

The ordination plot shows clearly that under these conditions flamingos were distributed across the whole of each etang, and fed at any location within an etang. The arrangement of the points for depth of feeding indicates that feeding flamingos are found in shallower water. Table 1 shows that on average birds feeding on the 10/5 were in water which came to just below the ankle.

The description of feeding techniques by Johnson (1983) suggests that this method (Marche, prehension tactile et filtrage) gives the flamingo greater sweep range with its neck.

The value for distance to nearest shelter on fig 14 is large in comparison with the value in fig 15 but not grouped with any other variables. This reinforces the suggestion that the flamingos range over the whole etang.

Thus, during days of low wind velocity flamingos are distributed and feed across the whole of the etang and birds occupy areas of shallow water, at various distances from shelter.

6.2.3 High velocity winds.

A CANOCO was performed as described for low velocity wind. On the 28/6/91 the mean wind velocity was 27.7kmhr^{-1}. Flamingos were recorded in only 25 of the 63 etangs.

The ordination plot groups the numbers of flamingos upwind and the total numbers of flamingos together. This reflects the fact that almost all the flamingos within an etang are found in the upwind half of the area, where shelter from the wind can be found.

The points for percentage of birds feeding, depth of water in which flamingos stood and distance to shelter are grouped together but separated from the upwind point. This illustrates that flamingos needing to feed during a Mistral move away from shelter. The distance that flamingos move from shelter is a relatively short distance when compared to their range during a day of low wind velocity. They also move to deeper water. Flamingos generally avoided the downwind half of the etang during a Mistral.

As water contained within the etang is pushed downwind during a Mistral bearing the *Artemia* with it, flamingos attempting to feed moved to deep water. Deeper water may offer increased stability for the flamingos, or *Artemia* may have moved deeper within the water column during the day (Britton *et al* 1986).

The distance that flamingos ventured away from shelter during high velocity winds ranged from 20-400m. Above 400m the disturbance by wind and waves probably prevents flamingos from feeding (fig 15).

The CANOCO plots were used to describe the interaction between the flamingo distribution and the environmental variables acting upon them. The trends shown by figs 14 and 15 are borne out by more conventional statistics.

As seen from fig 13 there was a significant negative correlation between wind strength and the numbers of flamingos recorded within the salines. There was a significant difference between the numbers of flamingos in etangs on days of low wind velocity and high wind velocity, 10/5 and 28/6 respectively, (Mann-Whitney U test P=0.03, DF=59). As described by the CANOCO plots, the distribution of flamingos within an etang also changed due to the influence of the wind. There was a significant difference in the numbers of flamingos counted in the downwind half of all the etangs occupied on these two days (Mann U P=0.0003, DF=59). This was not compensated for by an increase in the numbers in the upwind half (Mann U test P=0.08, DF=59, NS). It seems that flamingos in the downwind half of the etangs leave the salines during high velocity wind rather than move upwind to shelter.

As the wind velocity increased flamingos employed various compensatory behaviours to counteract its effect. During the peak of a Mistral many birds downwind left the salines, and the remaining birds gathered in the upwind half of the etang, close to dykes and islands where they can find shelter from the wind and no disturbance by waves.

During high winds water is displaced downwind carrying *Artemia*, which also under take a diurnal movement to lower in the water column. Flamingos are restricted to sheltered upwind areas. These factors combine to effectively stop them feeding. The only food available during these times is to be found in the mud and pools of water remaining up wind. Few flamingos move downwind to attempt to feed.

Etang Pavias is the only etang that offers both shelter and the opportunity to feed in the downwind half. This etang holds water within the favoured salinity range for *Artemia*, and has several islands in the down wind half, which provide shelter. (Fig 23).

With increasing mean wind velocity a greater proportion of the total numbers of flamingos within the salines shelter in Pavias (r_9=0.462 NS at P=0.05).

Clearly the violent winds of the Camargue present real problems for flamingos. Bouts of Mistral create an environment that is unfavourable. These conditions result in flamingos leaving the salines. My study did not address where the flamingos move to but Green & Hirons (1985) found that breeding flamingos fed 65km away from the colony. The distance that nesting flamingos are found from the colony is even greater in Spain where birds were located 120km away from the nest.

I measured only the mean wind velocity for the sampling period, but it is probably the gusts of wind that are the most disruptive as they are unpredictable and reach velocities of 2-3 times the mean velocity for the day.

The Mistral has a detrimental effect on feeding by flamingos in the most productive areas of the salines. This is compounded by the extra energetic and time costs incurred by moving to more sheltered areas.

6.3 TIME INDIVIDUALS ARE AWAY FROM THE NEST.

There is a significant difference in the time male and female flamingos are away from the nest (Mann-Whitney U test $P=0.005$ $DF=179$) with female flamingos spending longer away from the nest than males. Figs 18 and 19 provide length of descriptions of the time each sex is away from the nest.

Clearly breeding female flamingos require longer to obtain sufficient food than males. From measurements taken of corpses killed during the cold weather of 1985 (Johnson 1985), female flamingos are smaller than males by approximately 20%. The increased amount of time required for feeding could be a result of their smaller sized bill, making feeding less efficient. Females may simply be less efficient at feeding than males. Females could have depleted resources after producing the egg and require longer to feed. (This is unlikely as captive female flamingos have produced a series of 8 eggs in one season).

6.3.1 Beak measurements.

Only the measurements for tarsus and head length are significantly different. Other dimensions taken from the beaks of male and female flamingos have low P values but fail to reach $P=0.05$ (table 5). As the sample sizes are small these results have to be treated with caution. Other biometric perameters show that females are approximately 20% smaller than males with little over lap (Johnson 1985). Possibly females are less efficient at feeding as they have less filtering area.

6.4 EFFECTS OF WIND ON THE TIME AWAY FROM THE NEST.

It has been argued that a strong Mistral has a detrimental effect on the feeding of flamingos. Assuming, as above, that the time away from the nest is equivalent to the time required to gain sufficient food, then there may be an effect of wind on the time an individual is away from the nest.

From figs 20 and 21 it is clear that the mean time spent away from the colony, presumably foraging increased with the maximum gust during that interval for both sexes.

There is an upper limit to the time an individual can remain on the nest waiting for the partner to return. Shift lengths are longer on unsuccessful nests (Green and Hirons 1985). Also shifts were longer during 1984 than 1985.

He reported that there was a significant positive correlation between the rainfall during the previous September-December and breeding success the following year. It is suggested that this bout of autumn rain prevents hypersaline conditions developing in the etangs during the winter, and increases the numbers of invertebrates surviving through to spring. Higher temperatures during May would accelerate the spring increase in numbers of invertebrates.

However as shown above there is a significant positive correlation between the maximum gust strength and the time spent away from the nest. Analysing the meteorological data for April-July 1984 and 1985, shows that there were more bouts of high velocity winds during 1984 than 1985 (Paired t-test $P=0.01$ $DF=121$). Thus, the differences in the incubation shifts in 1984 and 1985 are also due to significantly more periods of high velocity winds in 1984 than 1985. High velocity winds increase the time required to acquire an amount of food, and as a result birds spend longer away foraging. These longer shifts mean more incubating birds are likely to abandon the nest.

The higher frequency of detrimental windy weather could also explain the higher nest failure rate in 1984. The multiple regression of Autumn rain fall and May temperatures used to show the influence of meteorological factors on breeding success may be enhanced by including the gust strength from April-July of the year.

7.0 CONCLUSIONS.

7.1 USE OF THE SALINES BY FLAMINGOS.

Flamingos can be found throughout the salines but occur in greatest numbers in the etangs (lagoons) within the conductivity range 90-110 milli siemens. In these etangs flamingos feed on the brine shrimp *Artemia* which is almost the sole prey available. The pumping regime during the summer can leave some etangs dry. This can reduce the area of suitable feeding grounds.

Etangs in close proximity to the breeding colony in Fangassier 1 have higher numbers of flamingos regardless of salinity of the water.

Flamingos feed mostly at night. The numbers of flamingos within the etangs in which they feed are not constant, but there is no obvious influx of birds at dusk to feed.

7.2 THE EFFECT OF WIND ON THE DISTRIBUTION AND FEEDING BY FLAMINGOS.

With increasing wind velocity more flamingos leave the salines for other areas. Birds that remain in etangs seek shelter behind islands and dykes but generally there is little opportunity for flamingos to feed during bouts of strong Mistral.

Any birds attempting to feed have to move away from shelter as the water, bearing *Artemia*, is pushed downwind. Birds are probably restricted to sheltered zones relativly close to shelter as there is much disturbance by gusts of wind and waves. Flamingos are found in deeper water during strong winds. This may ameliorate the effect of waves and gusts or, flamingos have to enter deeper water as *Artemia* have descended lower in the water column during the days of high velocity winds.

The proportion of the total number of birds in Pavias increases with mean wind velocity. Pavias has a number of islands in the downwind half of the etang, and during a strong Mistral this part of the etang offers flamingos the opportunity to shelter and feed. Pavias was the site of the old breeding island and it is possible that birds may collect there for historic reasons.

The violent winds of the Camargue create an environment within the salines that is detrimental to feeding by flamingos. The energetic costs of leaving the salines reduce the net return of feeding. Thus during bouts of high velocity winds it takes longer to acquire a standard unit of food.

7.3 TIME AWAY FROM THE NEST.

The time away from the nest is presumably the time required to forage. Female flamingos are away from the nest significantly longer than males. It seems that female flamingos are less efficient at feeding.

Females are approximatly 20% smaller than males in dimensions measured from corpses (Johnson 1985). This trend is not reflected in the differences in size of beak or size of the filtering area.

7.4 EFFECTS OF WIND ON THE TIME AWAY FROM THE NEST.

There is a significant positive correlation between the maximum gust during the time away from the nest and the mean absence from the nest for both males and females. As wind velocity increases it takes longer for bird foraging to acquire food.

There is an upper limit to the time a partner can remain away from the nest, and eventually the incubating bird abandons the egg. Green and Hirons (1985) state that incubation shifts were longer in 1984 than in 1985 and were longer on unsuccessful nests.

There were significantly more bouts of high velocity wind during April-July in 1984 than 1985. This could partly explain the differences in incubation shift between the the two years.

The multiple regression used by Green and Hirons (1985) to describe the breeding success may be improved by including the maximum gust each day during the breeding season.

RECOMMENDATIONS.

Flamingos rely greatly on the salines at all times of the year.
However the opportunities for flamingos to find shelter and feed during a Mistral are scarce, especially in the group of etangs with a conductivity range of 90-110 ms. This means the flamingos spend longer foraging during a mistral. The result of this is that many birds incubating abandon the nest as the partner fails to return.

This situation could be improved by having islands constructed in the downwind half of some of the etangs within the conductivity range (Estagnol, 500F). This would enable flamingos to feed in the most profitable areas.

Pavias is not included in cluster 4 of the ordination plot (fig. 11) so it can not be considered a site of optimal feeding. The water contained in Pavias has a conductivity of 103ms. No explanation can be offered as to why it is not more used, yet it is an important refuge for flamingos during a Mistral.

Greenwood and Earnshaw (1985) state that the Solvay process, which requires salt, is being phased out because of the difficulty of disposing of the environmentally unfriendly by-products NH_4Cl and $CaCl_2$. This could influence the longer term conservation measures for the Camargue flamingos.

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Appendix 1 Field data concerning the numbers and distribution of flamingos within the salines on the 10/5/91.

DATE	10/5/91	MEAN WIND = 7.3KmHr^{-1}				
ETANG	NUMBERS UPWIND	NUMBERS DOWNWIND	TOTAL NUMBERS	PERCENT FEEDING	STANDING DEPTH	DISTANCE TO SHELTER
ESQUINEAU 7	232	526	758	10	1	100
500F	300	161	461	10	2	100
ESTAGNOL`	60	0	60	50	2	500
QUENIN 3	0	322	322	20	2	400
QUENIN 1	568	6	574	50	3	200
ESQUINEAU 4	174	20	194	10	3	50
ESQUINEAU 5	0	50	50	10	2	200
MULETS	13	24	37	10	3	100
MAILLE						
TERMES	87	114	211	10	3	100
MACHINE	21	41	62	0	3	300
d'ENFER						
BARRAGE						
POINTES	34	4	38	10	2	800
CLOS 3						
CLOS 4						
CLOS 5						
CLOS 2	182	72	254	50	3	50
CLOS 1	145	0	145	0	2	30
GENEST	102	313	415	90	2	200
PAVIAS	105	882	987	10	3	100
DAME	9	0	9	0	3	100
GALERE						
VRS	22	5	27	0	3	20
ANNE	22	0	22	10	2	50
GOULE						
MOLINERI	10	18	28	10	2	20
POINTES DAME	34	30	64	50	2	
M. VERTS						
FARAMAN 1	173	88	261	50	5	20
FARAMAN 2	82	0	82	10	4	100
FARAMAN 3	15	18	38	10	4	100
CLOS VACHES						
Etg FMAN 6						
Etg FMAN 3						
Etg FMAN 2						
VANNEAU N						
VANNEAU S						
SIFFLEUR 1	0	5	5	0	3	80
SIFFLEUR S						
GARGATTE 2	9	0	9	50	4	100
GARGATTE 1	0	45	45	0	2	400
VRN	100	128	228	50	4	200
VAISSEAU 2	15	0	15	0	2	10
VAISSEAU 1						
Q'TAINE 1	2	8	810	0	3	500
Q'TAINE 3	129	73	212	80	3	600
VAL AGRICOLA						
Pt RASC 2						
GRND RASC	100	27	127	60	5	300
Q'TAINE 2	154	126	280	20	2	100
Q'TAINE 2A						
Mt d'ARNAUD	62	34	96	80	3	200
Pt RASC 1	11	46	57	50	3	50
BRISCON	47	97	144	50	2	600
GALABERT 1						
GALABERT 2	0	8	8	0	2	400
GALABERT 3	46	2	48			
ENF VIGNOLLE						
PEBRE	18	101	119	80	2	800
BEAUDUC						

Appendix 2. Field data of the number and distribution of flamingos within the salines on the 28/6/91.

DATE 28/6/91 MEAN WIND VELOCITY = 27.7$KmHr^{-1}$

ETANG	NUMBERS UPWIND	NUMBERS DOWNWIND	TOTAL NUMBERS	PERCENT FEEDING	STANDING DEPTH	DISTANCE TO SHELTER
ESQUINEAU 7						
500F	453	49	502	20	3	80
ESTAGNOL	707	0	707	30	4	80
QUENIN 3	5	0	5	100	2	50
QUENIN 1						
ESQUINEAU 4						
ESQUINEAU 5	36	0	36	2	2	50
MULETS	12	4	16	100	4	50
MAILLE	261	0	261	50	5	80
TERMES						
MACHINE						
d'ENFER						
BARRAGE						
POINTES						
CLOS 3						
CLOS 4						
CLOS 5						
CLOS 2						
CLOS 1						
GENEST	173	0	173	30	3	20
PAVIAS	500	13	513	10	3	50
DAME	0	91	91	10	4	800
GALERE	114	112	226	10	4	800
VRS	54	188	242	50	3	50
ANNE						
GOULE	9	0	9	0	2	30
MOLINERI	42	0	42	90	1	20
POINTES DAME	4	0	4	100	3	100
M. VERTS						
FARAMAN 1	138	0	138	10	4	200
FARAMAN 2						
FARAMAN 3	0	8	8	100	5	400
CLOS VACHES	22	0	22	100	5	200
Etg FMAN 6						
Etg FMAN 3						
Etg FMAN 2						
VANNEAU N						
VANNEAU S						
SIFFLEUR 1						
SIFFLEUR S						
GARGATTE 2						
GARGATTE 1						
VRN	32	4	36	80	1	20
VAISSEAU 2	0	216	216	20	2	20
VAISSEAU 1						
Q'TAINE 1						
Q'TAINE 3	16	0	16	100	4	20
VAL AGRICOLA						
PT de RASC 2						
GRND RASC	905	0	905	10	4	200
Q'TAINE 2						
Q'TAINE 2A						
M d'ARNAUD	72	0	72	90	4	20
Pt de RASC 1	0	18	18	100	4	100
BRISCON	148	0	148	90	4	20
GALABERT 1						
GALABERT 2						
GALABERT 3						
ENF VIGNOLLE	32	88	120	80	3	150
PEBRE						
BEAUDUC						